Technical Manual for Portable Alpha Counter

Model PAC-1SAGA

Eberline

A DIVISION OF
Thermo Electron
CORPORATION

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July 1, 1980

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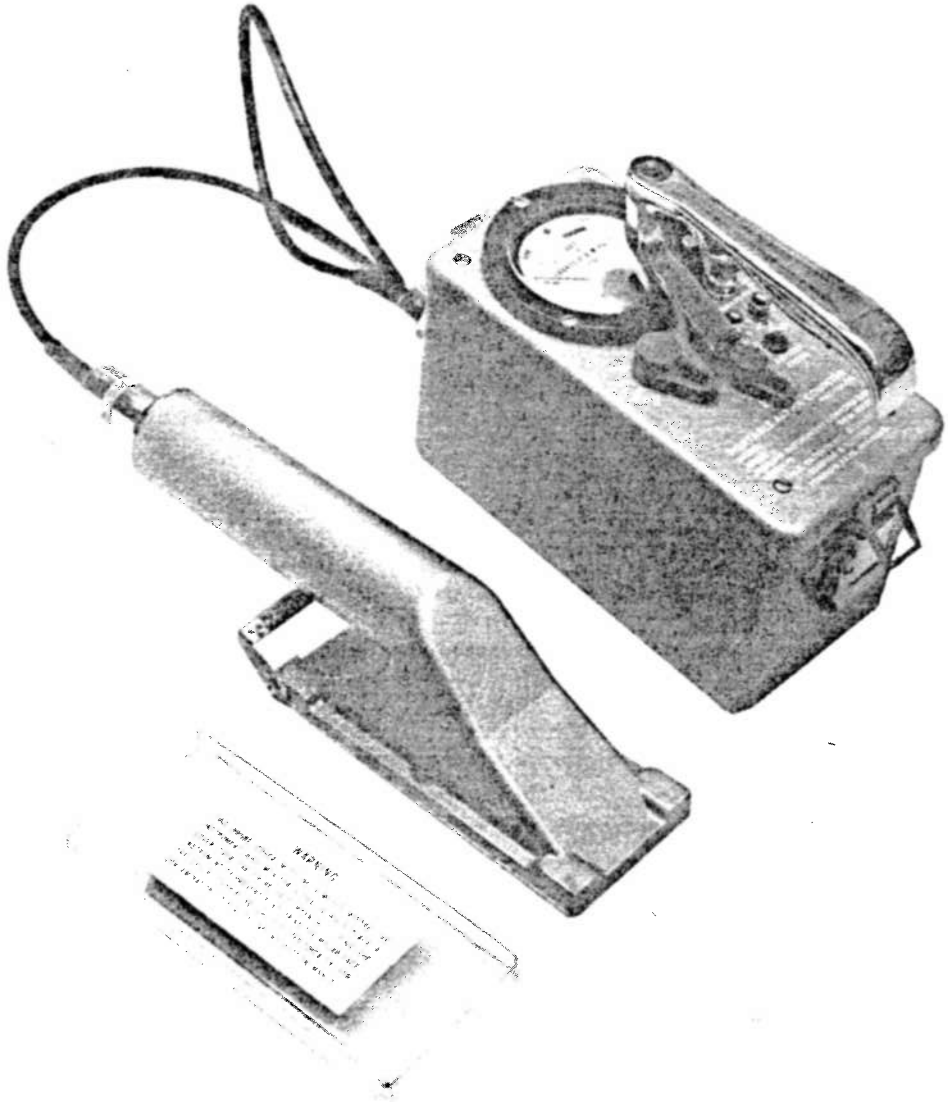


Figure 1-1. PAC-1SAGA with AC-3 Detector, AC-3FP Face Protector and CS-15 Source

SECTION I

GENERAL

A. PURPOSE

The PAC-1SAGA is a portable alpha and gamma detecting and measuring instrument.

When used for high energy gamma monitoring, it uses a Geiger-Mueller (G-M) detector which is mounted inside the instrument case. This detector presents a meter reading of zero to two roentgens per hour (R/h). The R/h reading is direct with no scale conversion and with the scale switch in the 2R position.

When used for alpha monitoring, it uses a scintillation type detector (AC-3) which is cable connected to the instrument. The instrument presents a meter reading of zero to two thousand counts per minute (0-2k cpm) with scale multiplier of X1.0, X10, X100, and X1K depending on scale switch setting. This provides a readable range of 0 to 2,000,000 cpm. Each scale is corrected for 50% geometry for a ^{239}Pu source.

In adverse conditions when the AC-3 alpha detector cannot be use satisfactorily, the PG-1 plutonium gamma detector may be substituted for the AC-3. The PG-1 is a scintillation type detector designed for detection of low energy gamma rays. Use of the PG-1 is limited to high level plutonium contamination because of natural gamma background and the low abundance of gamma rays from plutonium. The meter presentation is 0-2k cpm with the same scale multipliers as above, but with separate overall calibration compensation.

Aural monitoring provisions by means of a BNC connector on the front panel is included. Either a headset or speaker assembly may be used.

Front panel switches for meter reset and battery checking are also provided.

B. SPECIFICATIONS

1. Detectors

a. The G-M Gamma Detector

(1) Small, halogen-quenched G-M tube.

(2) Operating Voltage: 900 ± 30 VDC regulated.

(3) Temperature: -40°F to +130°F (-40°C to 54°C).

b. AC-3 Alpha Scintillation Detector

(1) Photomultiplier Tube: EMI Type 9524.

(2) Operating Voltage: 1240 ±30 VDC regulated.

(3) Active Area: 59 cm^2.

(4) Window Thickness: 0.5 mg/cm^2 aluminized mylar.

(5) Scintillation Crystal: ZnS(Ag).

(6) Efficiency: AC-3-7, 28% using a distributed ^{239}Pu source with discriminator (DISCR) set just above PM tube noise threshold. AC-3-8, 18%.

(7) Noise Threshold: Varies with PM tubes, but less than 50 cpm with DISCR set to the alpha plateau.

(8) Cable and Connectors: EIC cable No. CA-5-16, 36 inches long with waterproof connectors.

c. PG-1 Plutonium Gamma Scintillation Detector

(1) Photomultiplier Tube: EMI Type 9524.

(2) Operating Voltage: 1240 ±20 VDC regulated.

(3) Active Area: Approximately 5 cm^2.

(4) Scintillation Crystal: NaI(T1), 1 mm thick with a 0.001 inch thick aluminum light tight window. A mylar window and wire mesh provide protection for the aluminum window.

(5) Efficiency: Approximately 100% for 17 keV photons entering window.

(6) Noise Threshold: Varies with PM tubes.

(7) Cable and Connectors: Uses the same cable and connectors as the AC-3.

(8) Background: Typical gamma background (0.01 mR/h) yields a reading on the lower portion of the X10 scale.

2. Indicators

a. Meter

(1) Movement: 20 μA with less than 5000 ohms impedance.

(2) Scale (2 scales on one face)

(a) 2 R/h Scale: 0 to 2k mR per hour, scaled in 50 mR/h increments.

(b) 2k Scale: 0 to 2 thousand cpm, scaled in 50 cpm increments, markers in 500 cpm increments. Scale markers and rate in black color.

(c) Green Area: Battery condition "good" check area marked in green color on scale from 1100 to 1400 cpm increments.

(3) Scale Length: 90° or approximately 2-13/32 inches (6.11 cm).

(4) Linearity: ±10% full scale, all ranges, nominal.

b. Aural

(1) Headset: Single phone, Brush Elec. No. BA-201 with BNC cable connector normally used. Any crystal phone set with at least 100k ohms impedance may be used.

(2) Speaker: The EIC No. SK-1 speaker assembly is an optional item.

3. Temperature Characteristics: Maximum temperature operating conditions are -40°F to +130°F (-40°C to 54°C). For details, see Section V, Special Instructions.

4. Power Requirements: Typical 6V to 8V depending on type of battery used. Typical current drain is less than 50 mA depending on battery condition. Either the BP-1-X or the BP-2-X may be used. Terminal voltage of battery pack under instrument load should not be less than 5.8 V. For battery pack suggestions, see Section V, Special Instructions, Operating Temperature Conditions.

5. Controls

a. External Controls: The following operational controls are located on the front panel of the instrument:

(1) Power and scale switch.

(2) External detector selector switch, PG-1, AC-3.

(3) Discriminator Controls

(a) AC-3 DISCR

(b) PG-1 DISCR

(4) Battery check switch, BATT CHECK.

(5) Reset switch, RESET.

b. Internal Controls: The following calibration controls are inside the instrument and are normally adjusted during calibration only:

(1) 2 R/h

(2) X1K

(3) X100

(4) X10

(5) X1.0

(6) PG-1

6. Sensitivity: The basic instrument input sensitivity is less than 3 mV for a negative pulse with a rise time faster than 1 μsecond.

7. Check Source: Thorium-230. The EIC No. CS-15 check source is a 10,000 to 14,000 cpm alpha emitter deposited in a cup on the check source clip. This is a clip-on source used with the AC-3 detector and is an optional item.

8. Mechanical Characteristics

a. Size

(1) Height: 7-1/4 inches (18.4 cm).

(2) Width: 3-7/8 inches (9.84 cm).

(3) Length (without cable): 9 inches (22.86 cm).

b. Weight

(1) PAC-1SAGA (with "D" cells): 6-1/4 pounds (2.83 kg).

(2) AC-3 with cable: 1-3/4 pounds (0.79 kg).

(3) PG-1 with cable: 1-3/4 pounds (0.79 kg).

c. Environmental: The complete assembly is weather resistant.

d. Modules: The following subassemblies are plug-in type. The first three are etched circuit boards.

(1) High voltage power supply, P-7.

(2) Amp-Trigger assembly, P-8A.

(3) Meter accessory assembly, P-9A.

(4) Battery pack assembly (see Section V, Special Instruction, for types of cells that may be used).

e. Terminal Boards

(1) TB-1 Component Board: The detector load, pulse coupling, aural coupling, low voltage regulating and decoupling components are located on this board which is fixed to the chassis under the meter.

(2) TB-2 Component Board: The G-M detector voltage divider resistors and output pulse coupling capacitor are located on this board which is fixed to a chassis stand off post next to the front of the meter case.

(3) All other components are chassis or control panel mounted.

SECTION II
OPERATION

A. DESCRIPTION OF CONTROLS

1. Control Panel (see Figure 2-1)

a. Power and Scale Switch: This switch is located to the left of the carrying handle and may be set to OFF, 2R, X1K, X100, X10 and X1.0. This six position switch combines the function of turning the instrument on and selecting the scale desired.

b. External Detector Selector Switch: This switch is located under the carrying handle and may be set to AC-3 or PG-1. This two position switch selects the appropriate discriminator control applicable to the external detector being used.

c. Discriminator Controls: AC-3 and PG-1 DISCR controls are located to the right and next to the carrying handle. The controls determine the minimum size of pulse from the applicable detector that will be counted. Once adjusted, these controls should NOT be readjusted during normal monitoring. See paragraph E below.

d. BATT CHECK: The push button type switch is located to the right of the carrying handle. When this switch is held down the meter will indicate the battery condition. When the meter indicates in the green area, the batteries are good. If the meter indicates below the green area or fluctuates, the batteries should be replaced.

e. RESET Switch: This push button type switch is recess mounted in the forward part of the carrying handle. When operated, it discharges the meter integration capacitors and returns the meter reading to zero. This permits the rapid recheck of any reading and decreases recovery time when changing scales.

2. Internal Controls (see Figure 2-2)

The following calibration controls are located inside the instrument. They are normally adjusted during calibration only.

a. 2 R/h

b. X1K

c. X100

d. X10

e. X1.0

f. PG-1

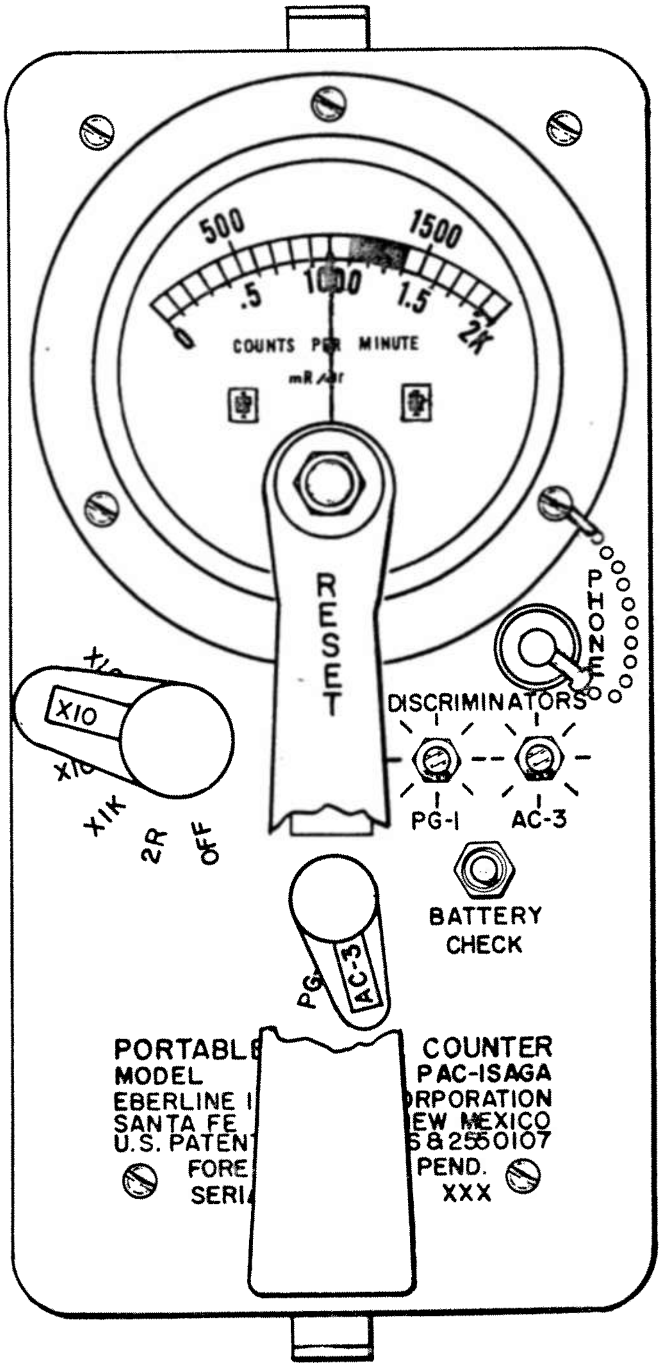


Figure 2-1. Control Panel, PAC-1SAGA

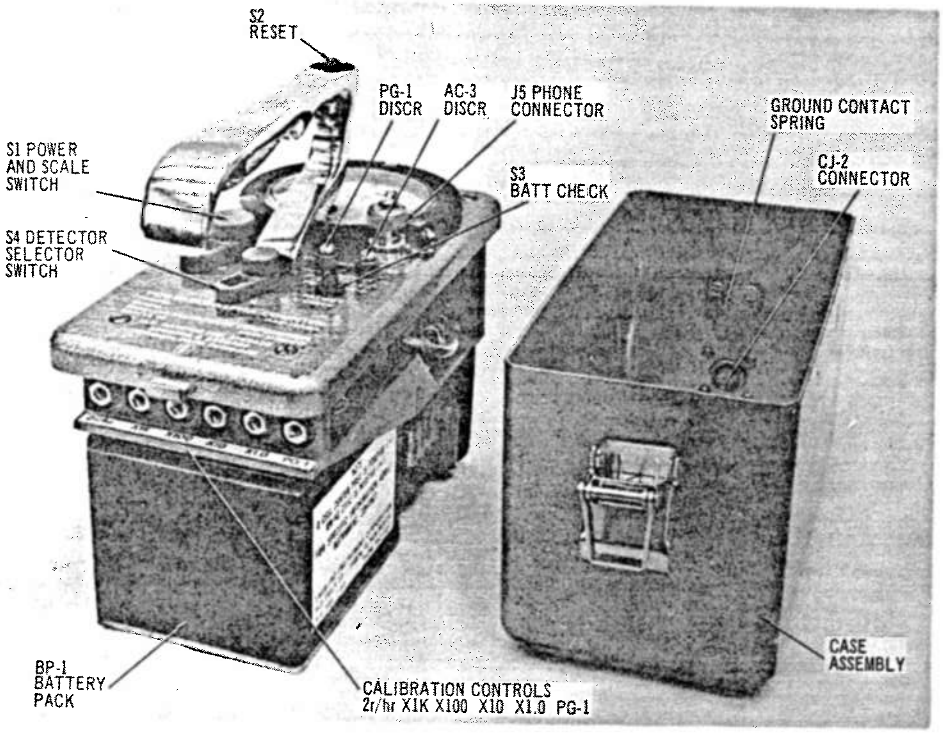


Figure 2-2. Location of Controls

B. PREPARATION FOR USE

1. Inspection (see Figure 1-1)

The instrument should be checked by the operator that all parts necessary for proper operation are present, such as, detector(s), detector cable, headset and check source.

The external physical condition should be checked for broken latches, damaged connectors, loose and/or broken knobs, handle, meter, etc.

Connect the detector cable to the case assembly. Then connect detector to cable.

NOTE

Tighten hand tight ONLY. DO NOT use tools.

Check external detector selector switch that it is in the proper position for the detector being used.

2. Safety Precautions

The AC-3-7 detector assembly mylar face is very easily damaged. DO NOT set the detector face down on ANY surface without the detector face protector in place except during normal monitoring.

C. USING THE INSTRUMENT

1. Starting the Instrument

Turn scale switch to the 2R position and check battery condition.

2. Check of Operation

a. G-M Gamma Detector (see Figure 2-3)

If a gamma source yielding at least 0.5 R/h is available, expose the instrument to the source and note the upscale indication. This reading should be approximately the calibrated gamma range value. If there is no gamma source available, set scale switch to 2R and note if there is any background reading. Under normal circumstances, there should be no reading.

b. AC-3-7 Alpha Detector

Turn scale switch to X1K position. Check that detector selector switch is in the AC-3 position.

Remove detector face protective cover and place check source in contact with detector face. Set scale switch to the scale which corresponds to the previous reading of the check source. The meter should indicate within ±20% of check source value.

Remove the check source and replace the detector face protective cover. Set scale switch to X1.0

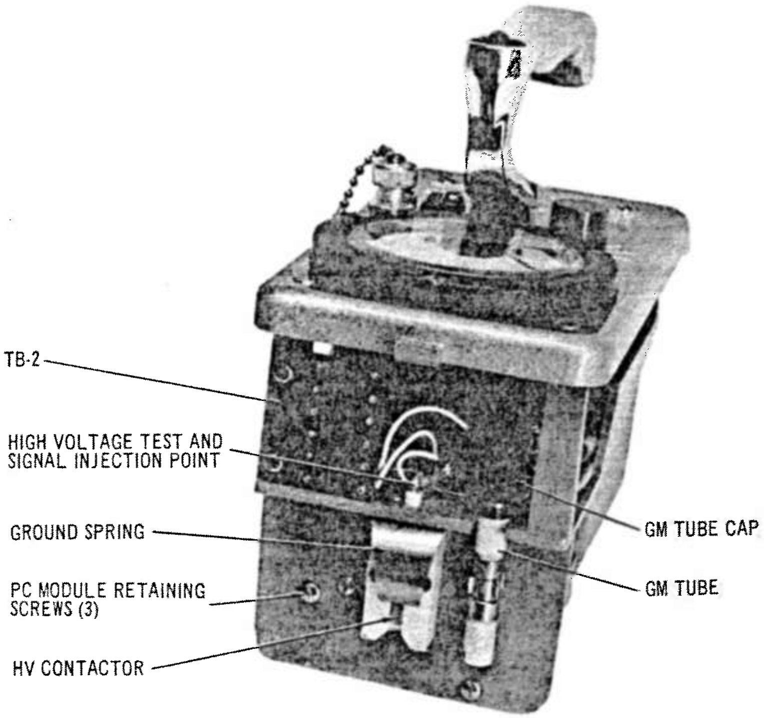

TB-2
HIGH VOLTAGE TEST AND SIGNAL INJECTION POINT
GROUND SPRING
PC MODULE RETAINING SCREWS (3)
HV CONTACTOR
GM TUBE CAP
GM TUBE

Figure 2-3. Front End of Electronics Chassis

scale. The normal background cpm should be observed on the meter.

c. PG-1 Plutonium Gamma Detector

Set detector switch to PG-1 and scale switch to a scale where a reading is observed. This will be background cpm, and may vary considerably depending on location. Reference Section I, B, subparagraph 1, c, (3) for approximate gamma background cpm. To further check the operation of the PG-1 detector, a ^{239}Pu source must be used. The meter reading minus normal background cpm should be 7% or greater of the alpha cpm of the source.

3. Interpretation of Indications

a. Meter Indication

The meter reading when monitoring should be observed carefully for several seconds before making the final observed average reading. Radioactive particles emission varies in time and may come in spurts. When the interval between particles is less than average, the meter will indicate a high reading. When the interval is greater than average, the meter will indicate a low reading. The instrument is designed to cancel out much of this fluctuation; however, the operator should watch the meter for a sufficient period of time to determine the average.

b. Using Scale Multipliers

After the average of observed readings is determined, multiply this reading by the scale multiplier as indicated by the scale switch. This figure will be the total cpm for that location. See Figure 2-1. Meter indicates 1000. The scale switch is set on X10 multiplier hence the total cpm is 10,000.

c. Very High Count Area Phenomenon, AC-3

When the detector is exposed to very high count areas of alpha radioactivity, two phenomena may be observed. First, the instrument may start to read at a greater than normal distance away from the surface. Second, as the detector continues to approach the surface, the meter may read full scale on the highest range and then start to decrease. This is due to the high light level generated in the scintillation crystal which causes a saturation effect in the instrument.

d. Gamma Sensitivity (see Figure 2-4)

When using the alpha probe in high gamma fields, the end window of the phototube scintillates and this is detected by the instrument giving a background reading. This gamma sensitivity will vary slightly from unit to unit and its effects can be minimized by turning the discriminator down at the loss of some calibration. If a high gamma background is suspected when using the alpha detector, its presence can be determined with the geiger tube.

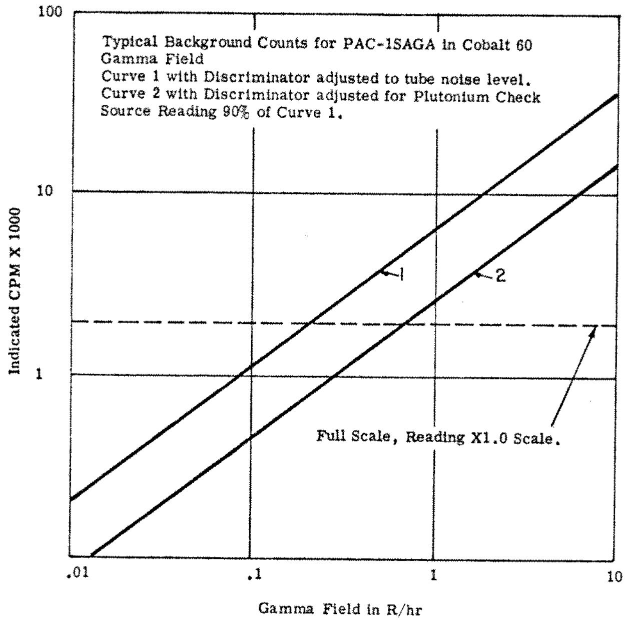


Figure 2-4. Background Counts in Gamma Field Using Alpha Detector

e. Variation in Calibration

If the check source does not read within ±20% of its value, and the instrument cannot readily be recalibrated, the following procedure should be used to obtain a correct alpha reading.

Divide the stated value of the check source by its actual reading to obtain a correction factor which must then be multiplied by the unknown source meter reading. As an example: The stated reading for the check source is 7500 cpm. Due to gamma discrimination, the check source reads only 5000 cpm. The correction factor is 7500 divided by 5000 or 1.5. With the probe on an unknown source, the meter indicates 100,000 cpm; this multiplied by the correction factor results in an actual value of 100,000 x 1.5 equals 150,000. In resume: "check source value" divided by the "check source meter reading" and multiplied by the "unknown source meter reading" equals "actual source value".

4. Specific Application Data

a. General (see Figure 7-1, General Schematic)

The PAC-1SAGA pulse rate, visual and aural readout, high and low voltage circuits are common to the three detectors. Switching provides for variation in circuitry required for the use of each detector. The G-M circuit has one calibration control and functions properly with detector selector switch in either position. The PG-1 and AC-3 use the same scale calibration controls with one additional control (PG-1) for overall compensation for PG-1 detector sensitivity. The AC-3 and PG-1 have individual discriminator controls, which are adjusted during calibration and should not be readjusted during normal monitoring. See Section III and IV for plateau curves and adjustments.

Requirements for Plateau Curve. A plateau curve should be run and DISCR adjustment made whenever any of the following conditions occur:

(1) Initial receipt of the assembly.

(2) A new detector is used.

(3) A detector face is repaired.

(4) Any plug-in assembly is changed.

(5) Temperature operating conditions below 0°F.

b. G-M Detector Applications

Placing the scale switch in the 2R position activates the high level gamma detector and its associated circuitry. Full scale reading is 2R/h.

CAUTION

A gamma field of sufficient intensity to cause the meter to indicate on this scale may be injurious to personnel.

The primary requirement for the proper operation of this circuit is that it should be calibrated. See Section IV, Maintenance.

When the instrument is used for gamma, no special distance considerations are necessary. The meter will indicate the strength of the gamma field in which the instrument is placed. Since the geiger tube is located at the front of the case, the highest sensitivity will result if the gamma source is ahead of the instrument. In this way, the gamma field will not be attenuated by the various components (especially the batteries) of the instrument.

c. AC-3 Alpha Detector Application

With the scale switch in any of the multiplier positions and detector selector switch in the AC-3 position, the external detector AC-3 will be activated. The meter indication times the scale multiplier equals the total alpha contamination for the 59 cm^2 detector area. The detector face should always be held as close as possible and parallel to the surface being checked.

If any off scale reading on the highest scale is encountered due to high intensity alpha radiation, an AC-3M-2 attenuator mask may be used to reduce the amount of radiation by approximately 50%. The total cpm for this situation would be meter reading times scale multiplier times 2.

d. PG-1 Gamma Detector Application

The PG-1 plutonium gamma detector has been especially designed to detect plutonium under adverse conditions which make alpha particle detection impossible. These adverse conditions may be snow, rain and/or dust. Any substance which may cover or coat the surface over the contamination will effectively prevent any alpha particles from being emitted. The method that may be used to detect the plutonium contamination in this case is the plutonium gamma detector, PG-1.

Readings can be taken with the detector using the following method: Hold the detector with the crystal end up and read the count rate, then take another reading with the detector turned over (crystal end down). The difference between the two readings is the count rate due to low energy gamma activity. It must be noted that any low energy gamma will be counted and not just that emitted from plutonium decay.

The distance between the detector and the contaminated surface will not affect the reading if the surface is large and radiates evenly.

D. ABNORMAL OPERATION CONDITIONS

1. Emergency AC-3 Detector Face Repair

Should the detector face be punctured or scratched during use in the field, any light striking the face will cause the meter to falsely indicate alpha activity. If the emergency of the situation demands continued use, the face can be temporarily repaired. Hold the face in direct sunlight or under a lamp, then shade the face with one finger. Observe the meter reading and locate the puncture or scratch by noting a decrease in the meter reading as the shadow of your finger passes over an area of the face.

CAUTION

Before applying the black lacquer to the apparent puncture, clean and decontaminate the detector as outlined in paragraph F below.

When the scratch or hole is located, place a small amount of black lacquer upon the suspected area. If the patch is complete, the meter reading will remain at zero when exposed to direct light.

If the meter reading drops only slightly, this indicates there are further holes or scratches in the face. Follow the above procedures until all the holes are patched.

If very large light leaks occur, the detector may saturate and the instrument will not respond to a source. Saturation can best be determined by observing a check source reading with the face alternately shadowed and then exposed to direct sunlight.

CAUTION

The patching compound will not pass alpha particles. When a large area of the face is covered by this compound, readings for distributed alpha sources of contamination must be corrected by that percentage of decrease in active area.

It is recommended that the detector face be replaced at the earliest possible opportunity if the active area of the detector has been reduced by an appreciable amount.

E. OPERATION IN TEMPERATURES BELOW 0°F

The DISCR control adjustments in this instrument must be checked for operation in temperatues from 0°F to -40°F. It is recommended the adjustment be made at -25°F and then only after the instrument has stabilized at that temperature. Refer to Section IV, paragraph C, DISCR adjustment.

After the DISCR. checking has been completed, check the instrument response by using check source CS-15 on the AC-3 detector. Determine percentage of error (paragraph C, 3, e above), if any, and apply to all subsequent readings.

The same percentage correction factor used with the AC-3 may be used with the PG-1 with a minimum of error.

F. SHUTDOWN FROM OPERATION

1. Check battery condition and turn scale switch to OFF.

2. Thoroughly clean the outside of the instrument by dusting or wiping with known clean cloths.

3. In adverse conditions, such as heavily contaminated, dusty and/or muddy areas, wash the instrument, connecting cable and detector under a stream of running water, using a brush if necessary. Be sure the connectors are tight and cover and can latches are secured before washing. Then wipe dry with clean cotton cloths of "throw away" material like paper towels or kleenex. See LASL handbook No. LA-1835 for other methods.

4. Replace detector face protector if applicable.

5. Store in a clean, dry place.

SECTION III

THEORY OF OPERATION

A. SYNOPSIS OF SYSTEM OPERATION

The detector, when in a radioactive field, will generate negative pulses. The pulses are capacitively coupled to a pulse amplifier. After amplification they are applied to a pulse height discriminator. If they are sufficient amplitude, they will trigger the monostable multivibrator circuit.

The output of the trigger circuit is direct coupled to the meter integration circuit. The integrating circuit averages the pulse rate of the trigger and presents it as a meter reading. The pulse from the trigger is also applied to a panel connector for aural monitoring.

B. FUNCTIONAL THEORY OF OPERATION

1. Detectors (see Figures 3-1 and 7-2)

a. G-M Detector

When a gamma photon causes a reaction in the G-M tube, an ion avalanche is developed. This causes a sharp drop in the anode voltage which appears across the bypass capacitor C5 as a negative pulse. The pulse is then applied to the detector load resistor R5 and is capacitively coupled to the pulse amplifier through C2.

b. AC-3 and PG-1 Detectors

When a radioactive particle penetrates the scintillation crystal, it generates photons which are detected by the photomultiplier tube. The PM tube converts the photon energy to current and amplifies this current. This amplified current is applied to the detector load resistor R5. The voltage drop across R5 is capacitively coupled to the pulse amplifier.

2. Electronics

a. P-8A, Pulse Amplifier, Pulse Height Discriminator and Monostable Multivibrator Assembly (Amp-Trigger)

(1) Pulse Amplifier (Figure 3-2)

The pulse amplifier consists of transistors Q201 and Q202 and associated circuitry.

The DISCR controls R8 or R18 and coupling capacitor C3 are part of the collector load impedance of Q202 but are separately mounted from the modular board.

Amplifiers Q201 and Q202 are common emitter stages. The overall voltage gain with DISCR at maximum is approximately 250.

Q201 bias is obtained through R201 from the collector. The collector load resistor is R202.

RT201 in the emitter circuit of Q201 is a temperature sensitive resistor with a positive temperature coefficient. This helps compensate for changes in transistor gain due to temperature changes.

Diode CR201 is provided to prevent damage to Q201 should the detector high voltage be shorted to ground.

Diode CR202 is included to limit the height of large input pulses. This prevents saturation of Q202 and increasing resolution time.

As the negative pulse from the detector is applied to the base of Q201, it reduces the current flow through the transistor and collector voltage rises accordingly.

This positive pulse is applied to the base of Q202 through coupling capacitor C201.

Bias for Q202 is obtained through R203 from the collector. The collector load is R204.

RT202 is a temperature sensitive resistor with a positive temperature coefficient. This helps compensate for changes in transistor gain due to temperature changes.

The DISCR, R8 or R18 is connected, through the coupling capacitor C3, from contactor "F" of the PC assembly and thru detector selector switch S4, to ground. As the DISCR is turned to a lower resistance, it reduces the AC impedance which decreases the gain and the size of the output pulse.

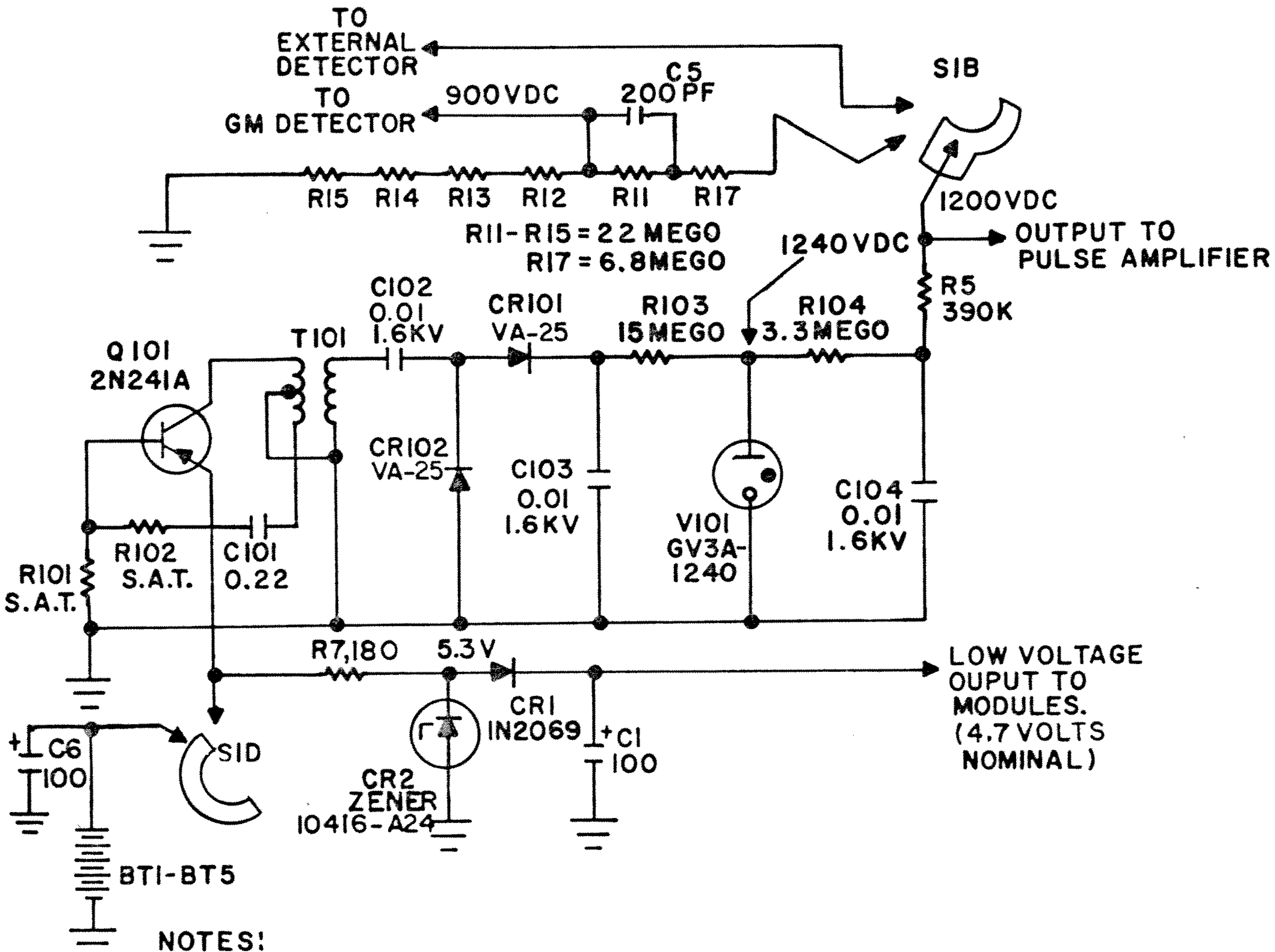
Q202 amplifies and inverts the positive pulse applied to its base. The negative pulse is capacitively coupled to the base of Q203 through the discriminator network.

(2) Pulse Height Discriminator (Figure 3-3)

Transistor Q203 is a common collector stage. The output of Q203 is direct coupled into Q204. Resistor R205 provides the bias for Q203.

Resistor R206 provides a small amount of negative feedback between Q203 and Q204 for greater stability.

Transistor Q204 is a common base stage which drives R208 and tunnel diode CR203. The output of Q204 approximates a current source to control CR203. When the



NOTES:
1. ALL CAPACITORS ARE MICROFARADS UNLESS OTHERWISE NOTED.
2. COMPONENT VALUES MAY DIFFER SLIGHTLY FROM ACTUAL VALUE IN THE INSTRUMENT.

Figure 3-1. High and Low Voltage Power Supplies with Detector Circuits

current through CR203 reaches 1 mA, it flips to its high voltage state. This is sufficient voltage to saturate the germanium transistor Q205.

Normally Q205 is cut off so its collector voltage is zero. When the tunnel diode flips to its high voltage state, Q205 saturates and its collector voltage is approximately 5 V. This transition is very fast. Q205 remains saturated as long as the current flow through the tunnel diode keeps it in its high voltage state. When the current through CR203 decreases sufficiently, the tunnel flips back and Q205 is cut off. C204 slows the fall time of the signal so it will no cause the trigger to cut off also.

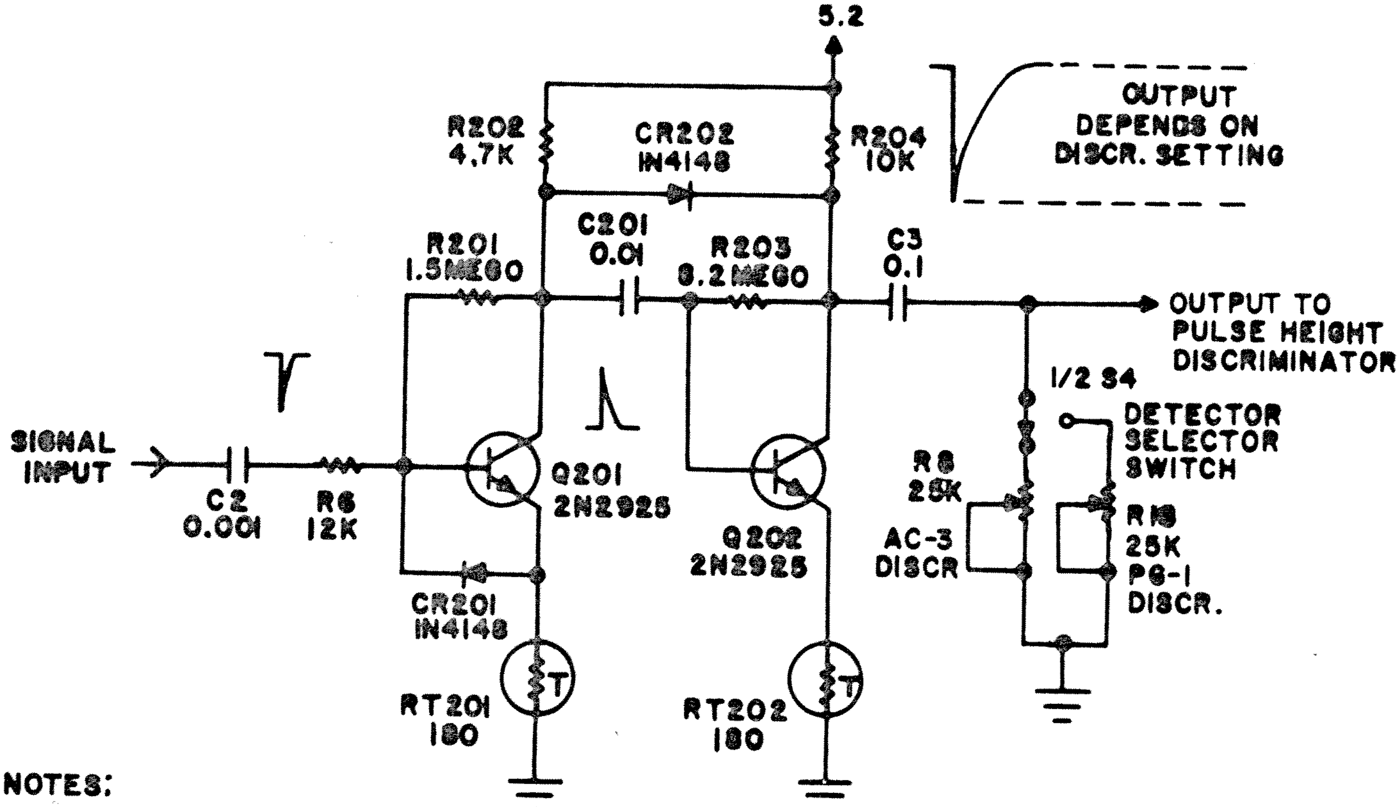
(3) Trigger Circuit (Monostable Multivibrator) (Figure 3-4)

The multivibrator consists of Q206 and Q207 and associated components. The RC timing components are separately mounted from the P-8A assembly.

In the stable state, the transistors are normally off. Q206 is held at cut off by R212 and R214. Q207 is held off by R211 and the selected calibration control.

When the large pulse from Q205 appears on the base of Q206, it turns on.

When Q206 turns on, a negative pulse is developed across R210 and is coupled to Q207 through one of the RC timing capacitors and resistor R211. This turns Q207 on.



NOTES:

1. ALL CAPACITORS ARE MICROFARADS UNLESS OTHERWISE NOTED.
2. COMPONENT VALUES MAY DIFFER SLIGHTLY FROM ACTUAL VALUE IN THE INSTRUMENT.
3 WAVEFORMS INDICATED ARE TYPICAL.

Figure 3-2. Schematic Pulse Amplifier

When Q207 conducts, a positive pulse is developed across the collector load resistor R214.

A portion of this positive pulse is fed back to Q206 base through resistor R212, holding Q206 in saturation.

The signal at the collector of Q206 holds the timing capacitor in a charging state, which holds Q207 in saturation. The selected capacitor in the RC circuitry has a charging path through its particular calibration control. The setting of the scale switch determines the combination of R and C used in the timing network. As the selected capacitor charges and the base of Q207 approaches the supply voltage potential, Q207 will start out of saturation.

As Q206 starts out of saturation, Q207 cuts off and its collector voltage drops to near ground potential.

This drop in collector voltage at Q207 is coupled to the base of Q206 and cuts it off.

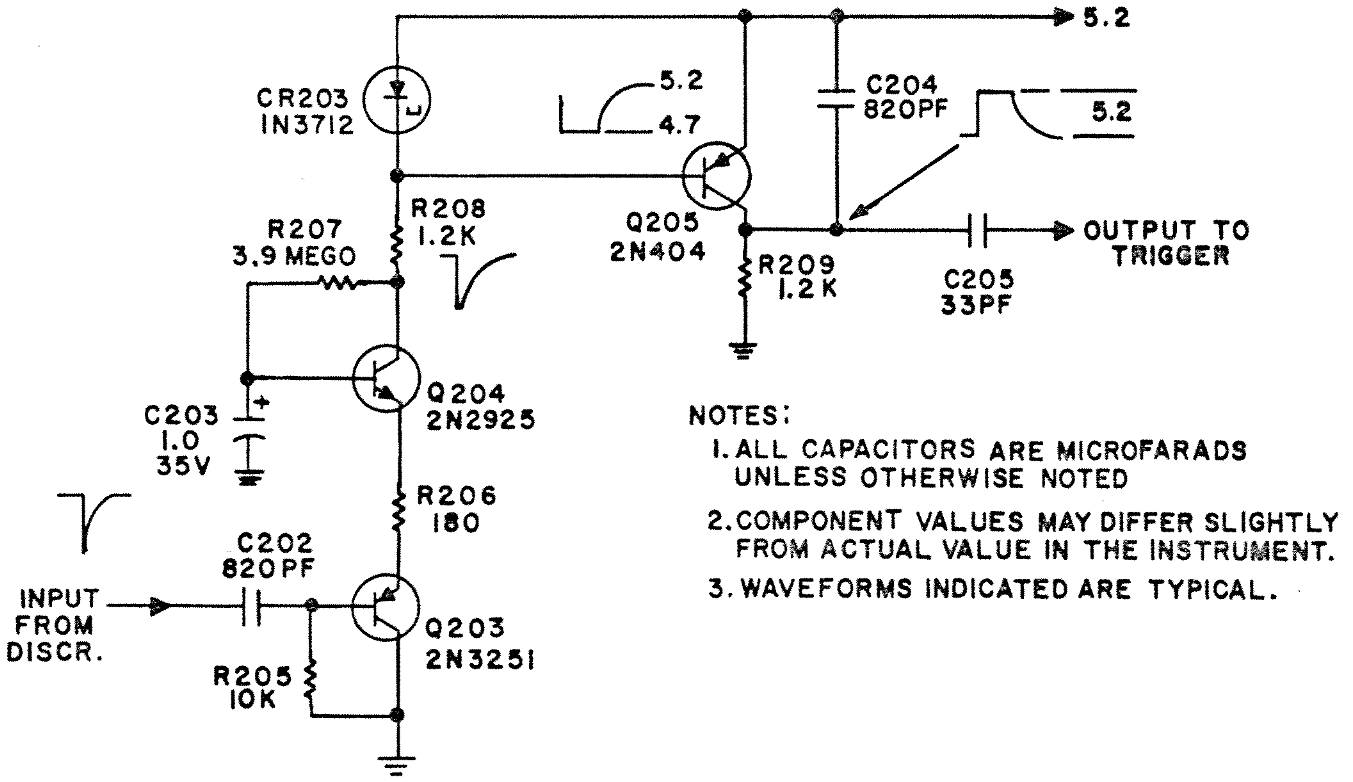
As the RC circuit attempts to swing positive, it is clipped by the diode CR204. The time that Q207 conducts is dependent on the capacitor selected by the scale switch and its associated calibration potentiometer adjustment.

b. P-9A, Meter Accessory Assembly

The accessory card contains the integration capacitors and temperature compensating shunt resistors for the meter indicator. This card also contains the timing capacitors for the trigger circuit which is part of the P-8A assembly. The meter is panel mounted, separate from the P-9A plug-in module.

The indicating meter and associated circuitry provides the readout capability. This reading is proportional to the rate of pulses received by the trigger circuit.

When Q207 conducts, current flows through the meter circuit (not part of the P-8A assembly) causing a volt-



NOTES:

1. ALL CAPACITORS ARE MICROFARADS UNLESS OTHERWISE NOTED
2. COMPONENT VALUES MAY DIFFER SLIGHTLY FROM ACTUAL VALUE IN THE INSTRUMENT.
3. WAVEFORMS INDICATED ARE TYPICAL.

Figure 3-3. Schematic Pulse Height Discriminator

age drop across the meter. This voltage charges the meter integration capacitor (C304, C303, C302 and C301), depending on the setting of the scale switch. When Q207 ceases to conduct, the selected capacitor discharges through the meter and also through the temperature compensating shunt resistance R301 and RT301.

c. P-7, High Voltage Power Supply (Figure 3-1)

The HV power supply is a transistorized etched circuit plug-in module used to supply a regulated 1240 VDC to the detector assembly. Q101, T101 and associated components, comprise a blocking oscillator circuit. T101 transformer secondary steps up the oscillator voltage and applies it to C102.

C102, C103, CR101 and CR102 comprise a voltage doubler circuit. The rectified voltage is regulated by V101, a 1240 V corona regulator tube.

C104 further filters the output voltage, which is then applied to the detector through load resistor R5.

The regulator tube current is adjusted for 15 μA with no load and 6.4 V applied. This adjustment is made by selecting R101 and is done at time of assembly.

C. ALPHA PARTICLE CHARACTERISTICS AND PAC-1SAGA INSTRUMENT RESPONSE

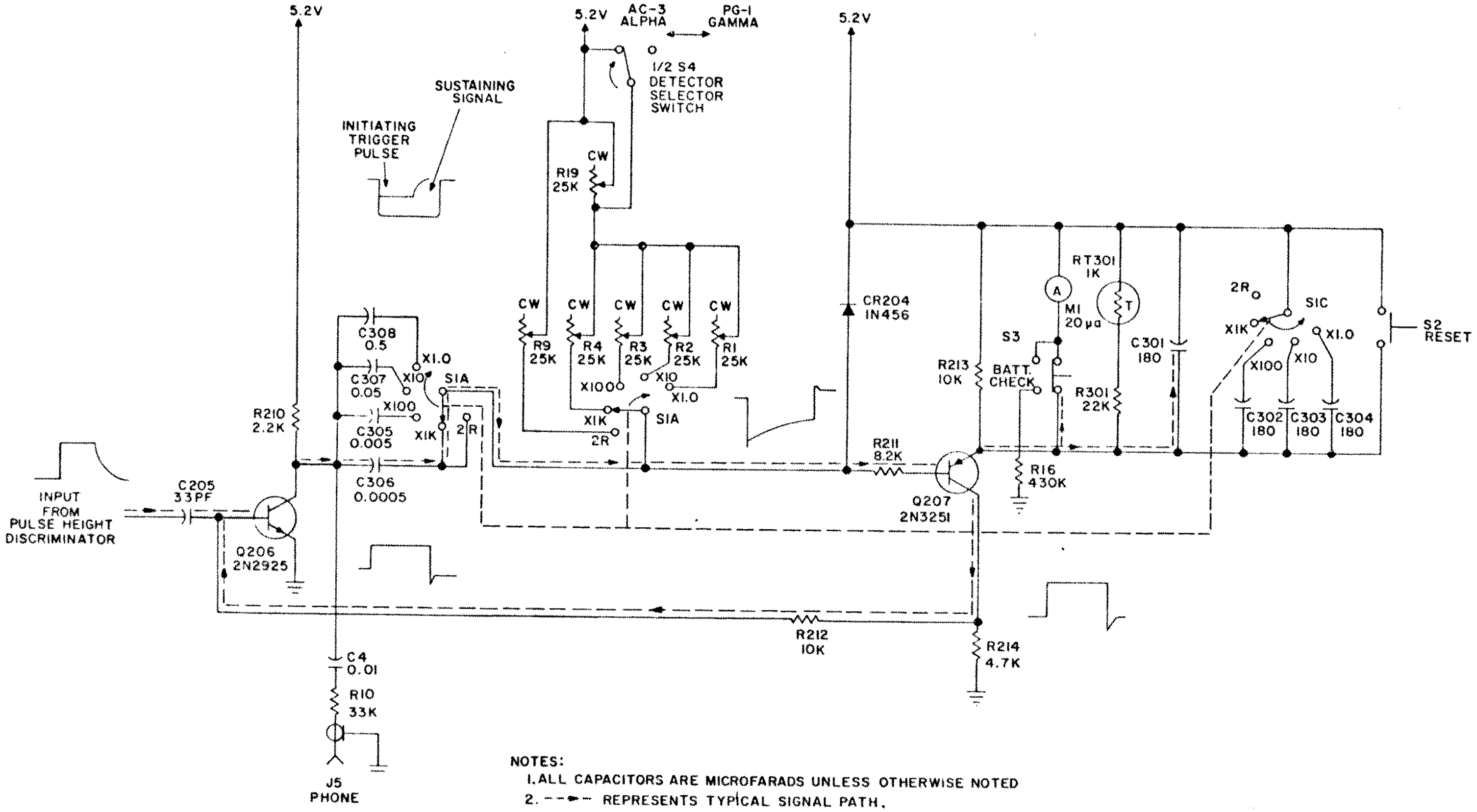
1. Alpha Radiation

Because of their large mass, alpha particles travel in straight paths, radiating in all directions from their source (see Figure 3-6). Energy is lost by collisions with air molecules. With their energy expended, forward progress stops and the alpha particles are no longer detectable.

The maximum range of alpha particles depends on their energy. Under standard conditions, the maximum range of alpha particles from ^{239}Pu is 1.4 inches. The maximum range of alpha particles from ^{238}U is 1.06 inches.

Water, paper and animal tissue reduce the range to approximately 1/1000 of that for air. Uranium 238 alpha particles penetrate about 0.001 inch of water, paper or animal tissue. Plutonium 239 alpha particles penetrate about 0.0014 inch.

A wet surface resulting from rain or early morning dew on the ground, on a truck, or any surface, cannot be monitored successfully. Heavy dust conditions can prevent a correct reading by dust settling over the contamination



NOTES:
1. ALL CAPACITORS ARE MICROFARADS UNLESS OTHERWISE NOTED
2. --➤-- REPRESENTS TYPICAL SIGNAL PATH.
3. COMPONENT VALUES MAY DIFFER SLIGHTLY FROM ACTUAL VALUE IN THE INSTRUMENT.
4. WAVEFORMS INDICATED ARE TYPICAL.
5. CW= CLOCKWISE ROTATION.

Figure 3-4. Schematic Trigger Circuit Portion, P-8A, P-9A and Chassis

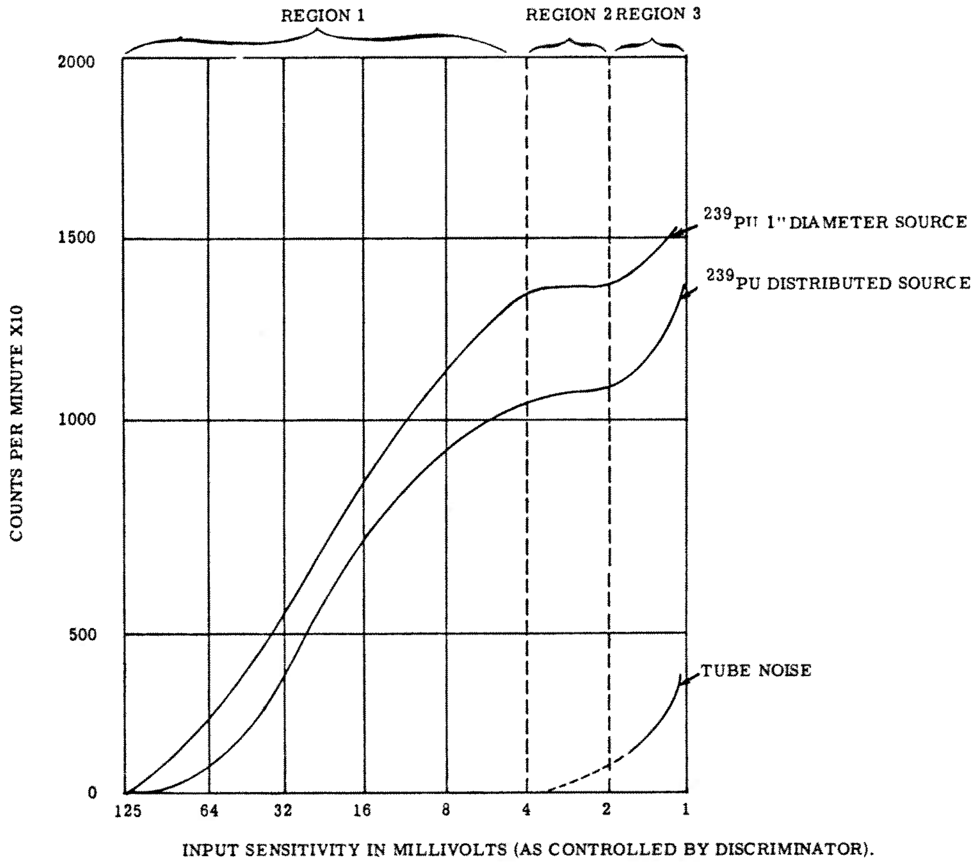


Figure 3-5. Typical Plateau Curves

area. A sheet of ordinary paper, the thickness of approximately 0.004 inch, will block out nearly all alpha particles. The operator must keep these facts in mind when monitoring any area.

It can be seen that it may be exceedingly difficult to detect alpha contamination under some conditions with the instrument working perfectly, because of the characteristics of alpha activity itself.

2. AC-3-7 Plateau Curves

Figure 3-5 is a graph of counts per minute versus instrument input sensitivity (DISCR setting) with various alpha test samples. The curves are called Plateau Curves.

In Region One, the sensitivity is so low that only pulses from higher energy alpha particles are coutned. Turning the DISCR in a clockwise direction causes the instrument to become more sensitive and more pulses are counted. As the DISCR setting is increased in the clockwise direction, a point is reached where nearly all alpha particles are counted. This is the start of the plateau and is identified by Region Two. Turning the DISCR further causes the instrument to become so sensitive it reads the photomultube noise also. This is identified by Region Three. Optimum instrument performance is obtained by setting the DISCR for operation just before Region Three.

3. AC-3 Detector Use

Another important factor is that alpha particles travel in every direction when emitted from their source. Figure 3-6 illustrates a cross section view of the approximate pattern of alpha emission from the source. Each line represents the trail of an individual particles showing the relation range and angle.

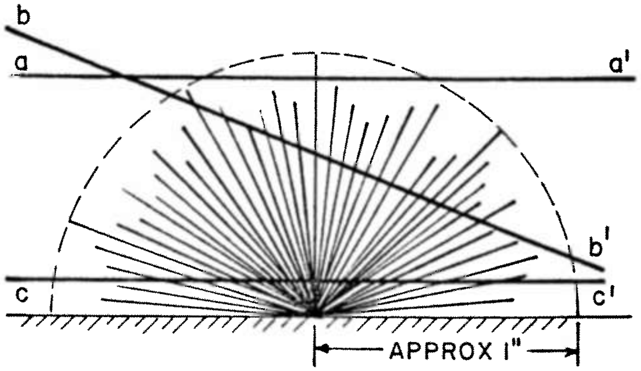


Figure 3-6. Typical Radiation Pattern

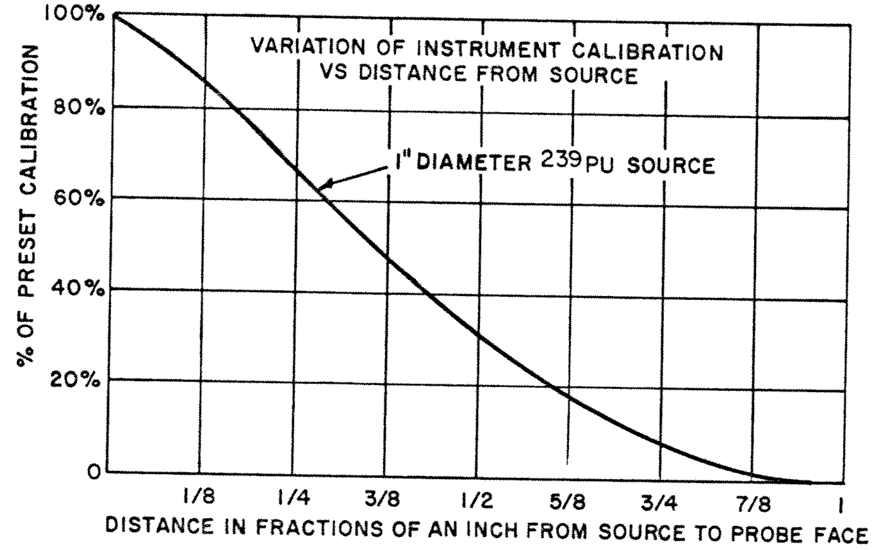
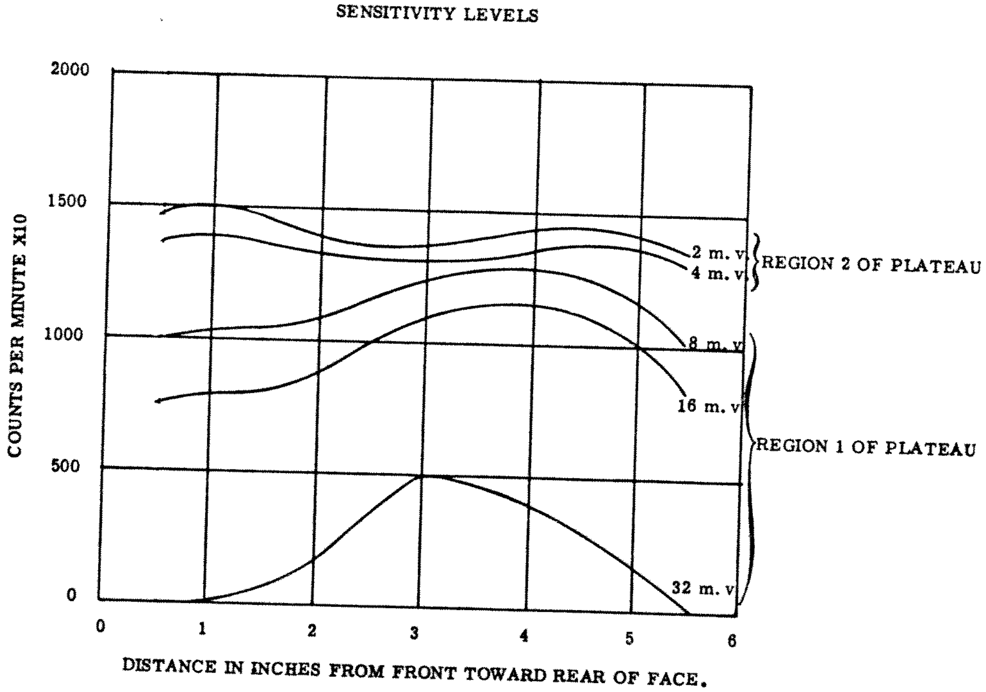


Figure 3-7. Typical Curve of Range and Calibration



TYPICAL CURVES OF NON-UNIFORMITY - FOR A ONE INCH DIAMETER ^{239} PU SOURCE MEASURED IN EQUAL INCREMENTS OF ONE INCH DISTANCES FROM THE FRONT TO THE REAR OF THE FACE

Figure 3-8. Typical Non-Uniformity Curves

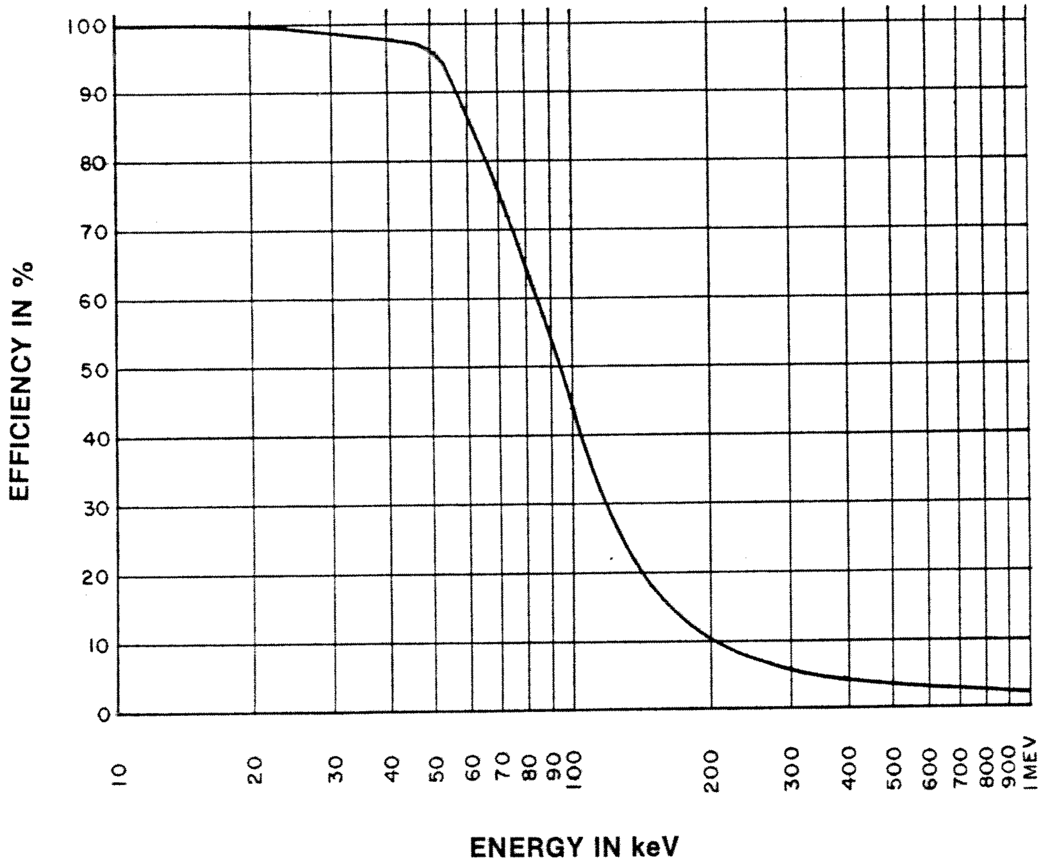


Figure 3-9. Calculated Energy Response Curve for NaI (Tl) 1mm Thick

As illustrated in Figure 3-6, the detector held in a position similar to line aa', would detect only the high energy particles, and only those which travel vertically. This would give a meter reading on the indicating instrument, but the reading would be much lower than the actual amount of alpha contamination present.

A detector held in a position similar to line bb' of Figure 3-6 would detect most of the alpha particles present under the right side, but only a few would be detected on the left side. Again, the indicating instrument would read, but the meter reading would be lower than the alpha contamination present.

With the detector in contact with the surface being monitored, line cc', nearly all alpha particles are counted and the indicating instrument will read the proper amount of contamination.

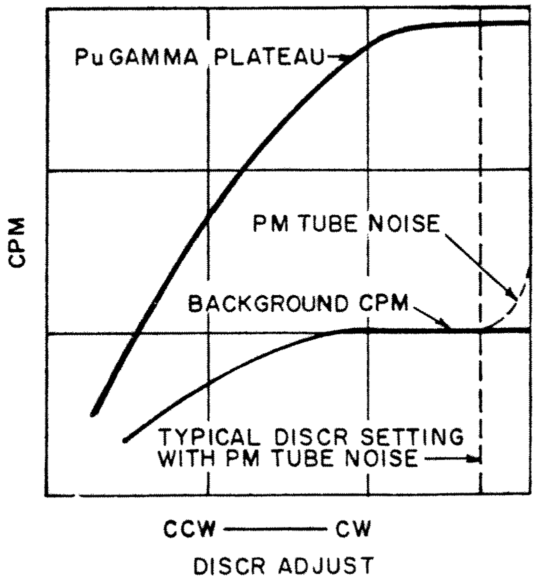


Figure 3-10. Typical Background and Source Plateaus

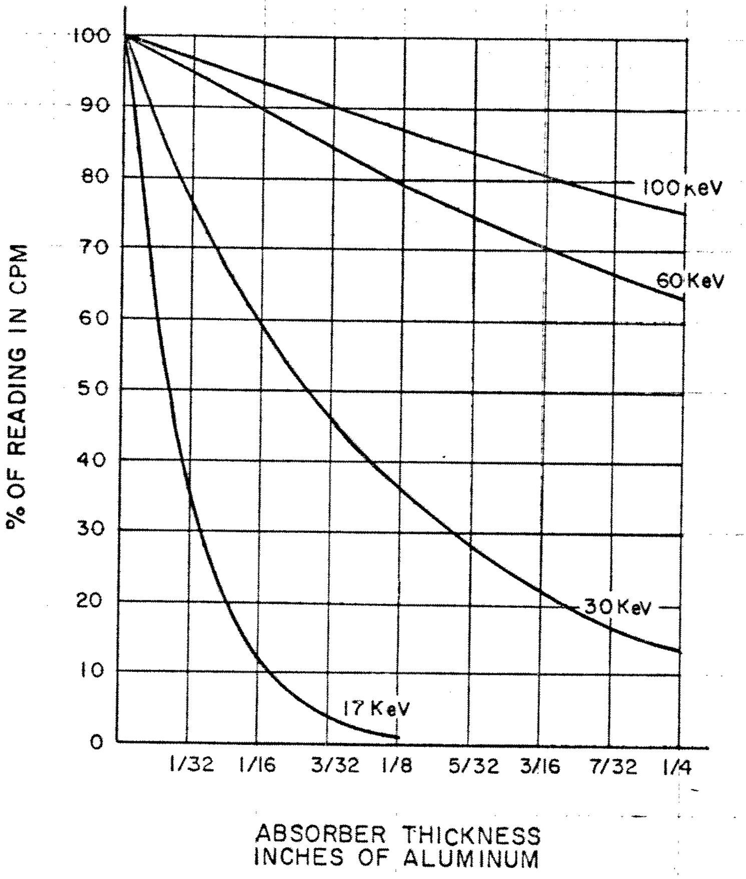


Figure 3-11. Attenuation Curves for Different Energy Gamma Radiation

4. AC-3 Calibration Versus Distance From Source

Figure 3-7 shows variation of instrument calibration versus distance from source. The distance is measured between the source and detector face. This variation is caused by fewer alpha particles striking the detector face.

5. AC-3 Non-Uniformity Curves

Figure 3-8 shows alpha detector non-uniformity characteristics. The detector has a non-uniformity factor (for a 1 inch diameter ^{239}Pu source) which is normally less than ±12% of the median of source counting when operated with the DISCR properly adjusted. The non-uniformity is measured by moving a ^{239}Pu source down, the center of the probe face and noting the meter variations as the source is moved. If the DISCR is set too low, the non-uniformity increases.

D. PLUTONIUM GAMMA CHARACTERISTICS AND PAC-1SAGA INSTRUMENT RESPONSE

1. Plutonium Gamma Photons

The PG-1 detector will detect gamma of any energy, but the efficiency of the crystal varies over the gamma spectrum. The greatest efficiency is obtained for energies less than 50 keV, but this level rapidly drops and reaches a low point for energies of 200 keV and higher. Refer to Figure 3-9 for the calculated energy response curve for the crystal.

Associated with the alpha decay of ^{239}Pu, a 17 keV gamma ray is emitted. The abundance of this gamma is about 4% of the alpha disintegrations or 4 gamma rays per 100 alpha particles. The PG-1 detects these gamma rays.

Normally, all ^{239}Pu contains some ^{240}Pu and ^{241}Pu. The ^{240}Pu alpha decays with a 6580 year half life and has a 50 keV gamma associated with its decay. ^{241}Pu beta decays into ^{241}Am with a 14 year half life. The ^{241}Am then alpha decays with a 470 year half life and has a 60 keV gamma associated with its decay. The abundance of these gamma rays depends on the original content of ^{240}Pu and ^{241}Pu in the ^{239}Pu material and upon its age. In most cases the abundance of these higher energy gamma rays will be low compared to the 17 keV gamma from the ^{239}Pu. However, in some cases they may become important.

A reading on the lower half of the X10 scale (less than 10,000 cpm) can normally be obtained from a uniformly distributed 1000 μg per square meter source of ^{239}Pu. It must be noted that contaminants other than ^{239}Pu or a shift in the energy spectrum of contaminants will cause differences in meter readings.

2. PG-1 Plateau Curves

Figure 3-10 is a graph of counts per minute versus input sensitivity (PG-1 DISCR setting) with a 1 inch diameter ^{239}Pu source.

NOTE

In most cases the DISCR setting for maximum sensitivity to Pu gamma will be at or near full clockwise position.

3. PG-1 Detector Use

Reference Section II, c, 4, d for determination of incident or background gamma cpm.

To further evaluate the gamma activity, the energy of the gamma rays being measured can be determined by use of attenuators. Due to the different mass absorption coefficient of the different energies, the attenuation is different in a given thickness of material. Figure 3-11 shows the attenuation vs. thickness of aluminum placed in front of the crystal for several different energy gamma rays.

SECTION IV

MAINTENANCE

A. DISASSEMBLY AND REASSEMBLY

1. Disassembly

a. PAC-1SAGA

Basically the complete instrument consists of three sub-sections.

They are:

(1) Detector assembly

(2) Detector cable assembly

(3) Electronic chassis, control panel and plug-in modules.

The electronic chassis and control panel may be removed from the case by releasing the spring loaded latches and lifting the electronics section out of the case.

WARNING

The high voltage in this instrument is dangerous. Avoid contact with high voltage points.

To prevent possible damage to the detector or cable when disassembly is necessary, it is recommended that the detector assembly be removed from the cable before the cable is disconnected from the case.

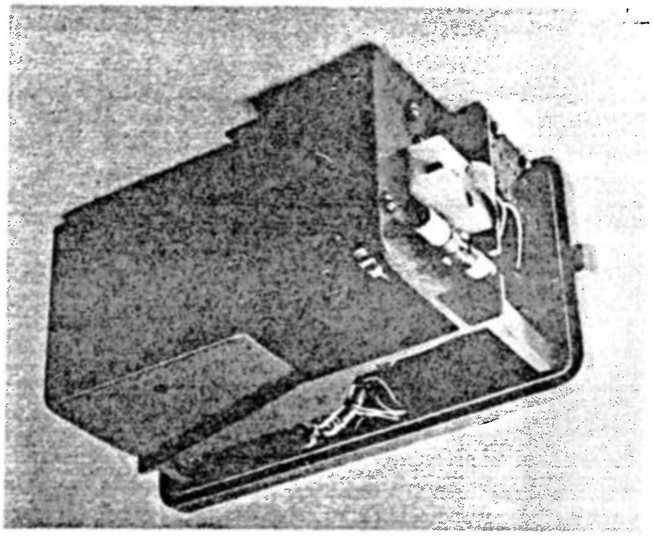


Figure 4-1. Electronic Chassis and Cover Assembly

b. PC Assemblies

To remove the modular PC boards, remove the retaining screw then work the board from side to side, maintaining a constant pull until the board is free.

CAUTION

DO NOT work the board loose with a front to back movement.

WARNING

Short high voltage to ground before removing P-7 assembly. See Figures 7-1 and 2-3.

c. Battery Pack Assemblies

(1) BP-1

The BP-1 batteries may be removed and/or replaced by removing the two binder head screws in the phenolic cover. This cover will be spring loaded if the assembly contains batteries. Hold cover securely in place until both screws are removed. Remove cover and batteries.

The BP-1 assembly retaining screws are recess mounted through the phenolic cover.

(2) BP-2

The BP-2 assembly must be removed in order to service the batteries.

The assemblies may be removed by disengaging the retaining screws.

On the BP-2, the retaining screws are fillister head captive type located on the side of the assembly.

Remove the two flathead screws in the black cover for access to the LR-5 or Mallory mercury batteries.

2. Reassembly

When installing the PC assemblies, be sure they are positioned correctly before they are pushed into the socket. Replace retaining screw.

When replacing the electronics in the case, align the HV contactor in the case with the one on the chassis. Gently slide the chassis into case. Be sure the case edge fits properly in the seal groove on the panel. Secure latches.

Connect the cable to the case and the detector to the cable. Hand tight ONLY. Do not use tools.

When replacing the batteries or battery pack assembly, use the reverse of the disassembly procedure outlined above.

CAUTION

> When reassembling either battery pack to the chassis, be sure the battery connectors line up before forcing it into place and securing it with the retaining screws.

B. PREVENTIVE MAINTENANCE

The PAC-1SAGA has been designed as a waterproof instrument. However, the instrument and accessories should be kept as clean and dry as possible.

1. Cleaning the assembly

The instrument should be removed from its case periodically and checked for moisture condensation and dirt. See paragraph A, Disassembly.

If moisture is evident inside the instrument, permit to "air" dry before reassembly. Inspect O-ring seal around instrument edge for damage.

To remove dust and dirt, use a camel hair brush to loosen dirt and a vacuum cleaner to remove the dirt. Do not use a blower since this may cause dirt to lodge in places where critical voltages exist and provide leakage paths which may cause erratic readings and/or failure of the instrument.

Remove the detector from the cable and the cable from the instrument. Inspect all connectors for dirt, metal filings and moisture. Clean the connectors with a camel hair brush and alcohol. DO NOT use any other type of solvent. Other types of solvent may cause deterioration of the insulation and/or the surfaces adjacent to the connector.

2. Decontamination

Refer to Section II, E, Shutdown from Operation for decontamination procedures.

3. Batteries

Always replace the batteries whenever their check reading is below the green area on the meter.

Never leave the batteries in the instrument if it is to be in an inactive status for any length of time.

When the wet cell pack (BP-2-1) is used, recharge at monthly intervals or sooner if the meter reading on BATT CHECK drops below green area or an unsteady reading is observed when the check is made.

C. DISCR ADJUSTMENT

1. AC-3

NOTE

> This procedure is based on normal gamma background. High gamma fields will cause background count. Refer to Figure 2-4.

With the AC-3 detector connected and the detector selector switch set to AC-3, turn the scale switch to X1.0 position. Check battery condition. Do not remove detector face protective cover. Adjust the AC-3 DISCR until meter indicates approximately 50 cpm. If the headset is also used, approximately 15 to 20 clicks per minute will be heard. This is the noise threshold of the PM tube. The difference between the number of clicks heard and the meter reading is due to detector efficiency. The efficiency compensation is built into the instrument. Lock the DISCR control and recheck the background. Readjust DISCR if necessary.

NOTE

> Occasionally, the average meter reading may be less than 50 cpm with the DISCR completely clockwise. This does not indicate a bad instrument but a low noise PM tube. Lock DISCR fully clockwise and continue with adjustments and calibration.

2. PG-1 (Refer to Figure 3-10 Typical Background and Source Plateaus).

With the PG-1 detector connected and the detector selector switch in the PG-1 position, turn scale switch to a multiplier position where the meter indicates within the scale limits with no gamma sources present. Check battery condition. Reference section 1, B, subparagraph 1, c, (8) for approximate gamma background cpm.

NOTE

> The following adjustments can be made easier by shielding the PG-1 to reduce background effect.

Set the DISCR to the full clockwise position. Then, while observing the meter, move the DISCR counterclockwise in 30° increments. Should there be no change in the average meter reading in the first 1/2 turn, lock the DISCR in the full clockwise position.

Should the meter reading show a decrease in the first 1/2 turn, determine the point on the DISCR adjustment where no further decrease in meter reading occurs and lock the control. This decrease is PM tube noise and must be reduced to minimum.

D. CALIBRATION

1. AC-3 (Refer to Section IV, Theory of Operation)

a. Equipment Required

Plutonium alpha calibration standards, set of 4, one for each scale, EIC catalog no. S94-1.

b. Procedure (see Figures 2-2 and 3-5)

(1) Remove the instrument from the can. Short high voltage to ground. Using a shielded clip lead, connect center conductor to the center post of CJ-2 connector in can, connect the opposite end to the solder terminal above the high voltage block on the chassis. Connect shield of cable to the ground spring contacts in the can and on the chassis.

(2) With the AC-3 detector connected and the detector selector switch in the AC-3 position, set scale switch to the X1.0 position. Check battery condition. Check background CPM. Refer to paragraph C, 1, above.

(3) Remove the protective cover and place detector on the applicable standard source.

(4) Adjust the X1.0 calibration potentiometer until the average meter reading matches the cpm of the standard source.

(5) Rotate the detector on the source 180° and observe the average meter reading. If this reading differs from the source cpm, adjust the calibration potentiometer until the average of the two readings equals the standard source cpm. Lock the calibration control. The two readings above should not deviate from the standard source cpm by more than 10%.

(6) Repeat steps (3) thru (5) for other scales, changing scale switch and standard source as required.

(7) Recheck the DISCR adjustment, paragraph C1 above. Reset DISCR if necessary.

(8) Should it be necessary to readjust the DISCR, it is recommended that the entire calibration be rechecked.

(9) Turn the instrument OFF. Short the high voltage to ground. Remove the shielded clip lead. Replace the instrument in the can or proceed to the PG-1 calibration for further instrument calibration.

2. PG-1 (Refer to Section IV, Theory of Operation)

NOTE

The AC-3 calibration must be completed prior to PG-1 calibration.

a. Equipment Required

Pulse generator capable of producing a negative pulse 3 mV minimum amplitude with a rise time faster than one μsecond.

b. Procedure

(1) Remove the instrument from the can if applicable. Remove the P-7 high voltage power supply assembly. Using a shielded clip lead, connect the output of the pulser to the instrument. The center conductor should connect to the solder terminal above the high voltage block on the chassis and the shield to the ground spring adjacent to the block. Check detector selector switch that it is in the PG-1 position.

(2) Turn both instruments ON and allow time to stabilize if necessary. Adjust pulser output to 15,000 pulses per minute (ppm). Set scale switch to X100 scale. Adjust PG-1 calibration control until the meter indicates 1500 cpm. Lock the calibration control.

(3) Turn both instruments to OFF. Remove clip lead and replace P-7 assembly.

(4) Replace the instrument in the can. Connect PG-1 detector to cable. Turn instrument ON. Recheck PG-1 DISCR adjustment, refer to paragraph C2 above. Keep sources and detector well separated during this recheck. Place detector on the standard source which is in the 10^6 cpm range. The instrument should read 7% or greater of the standard cpm value.

(5) Turn instrument OFF and proceed to the G-M detector calibration for final step in complete instrument calibration.

3. 2R Scale

a. Source Required: A calibrated gamma range with a field of at least 1.5 R/h.

CAUTION

A 1.5 R/h field can be injurious to personnel. Apply normal gamma range precautions when calibrating this scale.

b. Procedure

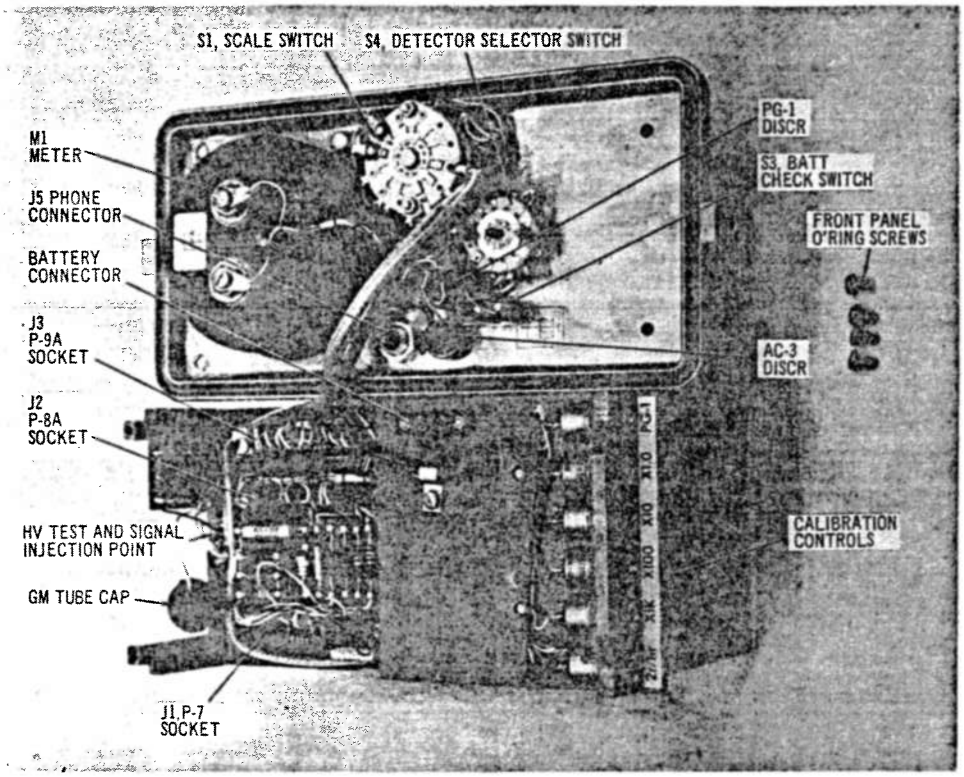


Figure 4-2. Chassis and Panel Layout

(1) The external detectors or cable are not required during this calibration.

(2) Turn instrument ON to the 2R scale and check battery condition.

(3) This detector circuit will work satisfactorily with the detector selector switch in either position provided paragraph C1 and 2 above has been done.

(4) Place the instrument at the 1.5 R/h position on the calibrated gamma range. The front of the instrument should be toward the source of gamma radiation.

(5) Expose the instrument to the source and take the meter reading. Replace source in holder.

(6) Remove instrument from can and adjust 2 R/hr calibration control. Clockwise adjustment will increase meter reading and counterclockwise will decrease the reading.

(7) Repeat steps 3 through 5 until average meter reading indicates the 1.5 R/h of the gamma range.

E. REPAIR PRECAUTIONS

See disassembly and reassembly.

1. Batteries: Remove batteries or battery pack before starting any continuity checks or replacement of components on the chassis assembly.

2. Meter Safety: The indicating meter in this instrument is very delicate. Should it be necessary to check continuity in the instrument, place a jumper across the meter terminals.

3. Soldering

   a. Always use heat sinks on diodes and transistors.

   b. Use a low wattage soldering iron on PC assemblies.

   c. Do not overheat the PC boards.

4. Chassis and Panel Repair (Figure 4-2)

Should it be necessary to repair or replace any of the components on the chassis or panel, remove the four O-ring screws at the corners of the control panel. The panel will then unfold approximately 90° away from the chassis, providing easy access to components and terminals. Do not lose the O-ring screws since they provide part of the waterproof feature of the instrument.

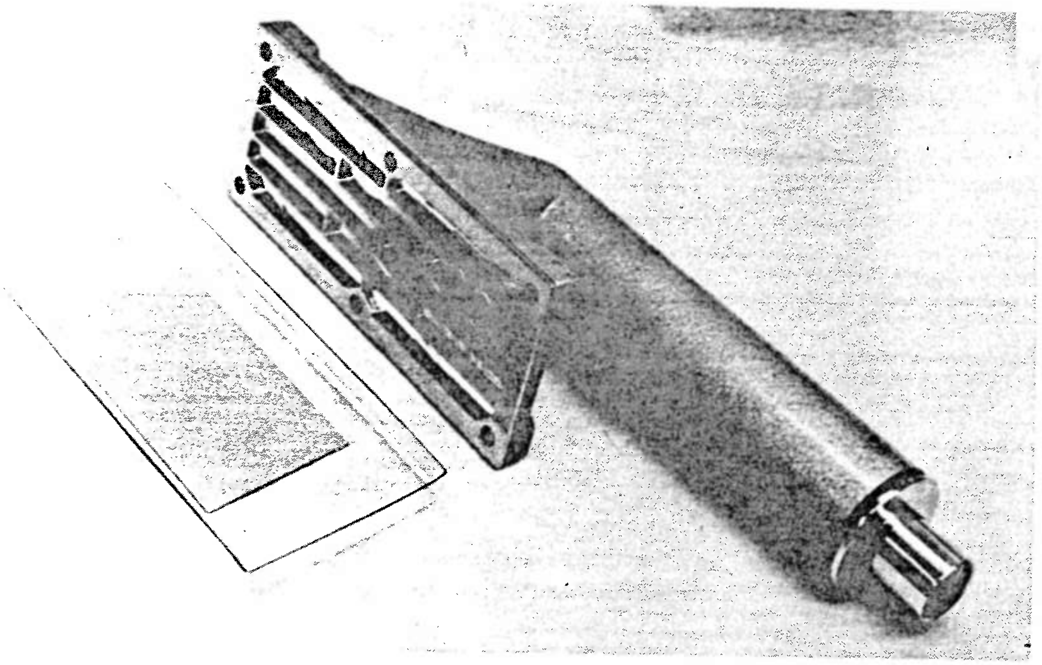


Figure 4-3. AC-3-7 Detector Assembly

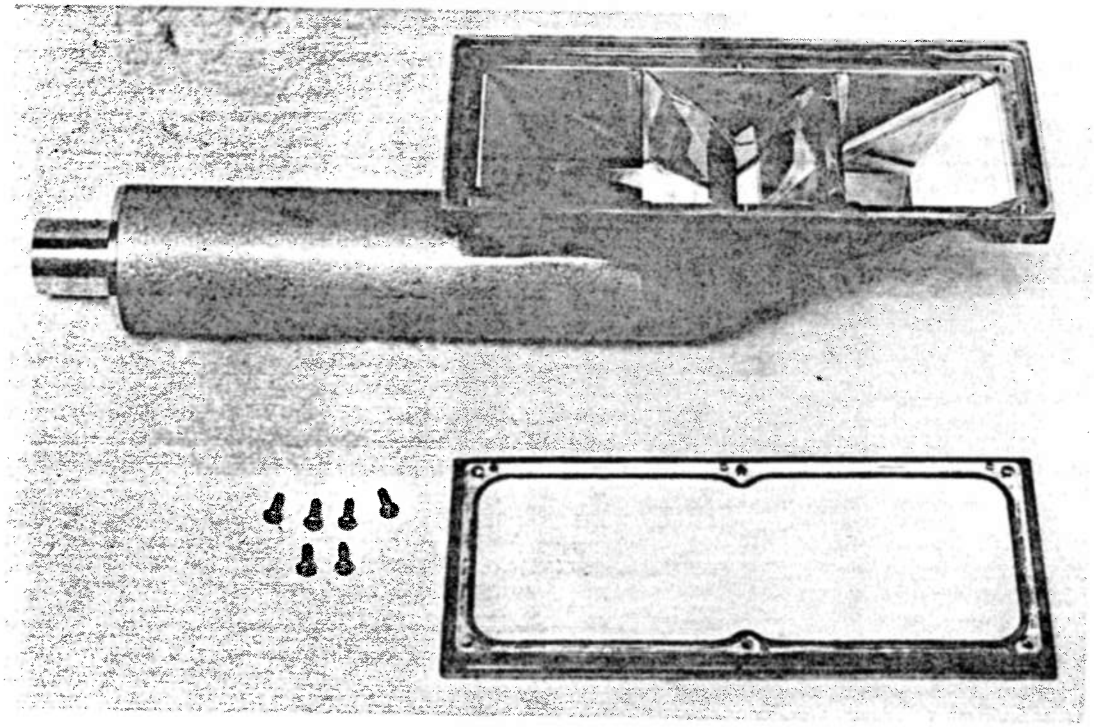


Figure 4-4. AC-3-7 Face Removed Showing Optical Prism

F. TROUBLESHOOTING

The most probable source of trouble in the PAC-1SAGA is dirty or corroded contacts. This trouble may be located at any of the plug-in module sockets or cable connectors. The best procedure for localizing the trouble is suggested below.

1. Clean detector cable connectors (primarily be sure the inner conductor contact and insulator is clean).

2. Clean each of the plug-in module contactors on each assembly (use a soft pencil eraser; do not use any abrasive).

3. Bend plug-in socket contacts together (use a soldering aid or similar tool).

4. While each subassembly is out of the instrument, inspect each for broken and/or burnt components, broken leads and solder joints and broken conductor paths on the etched board.

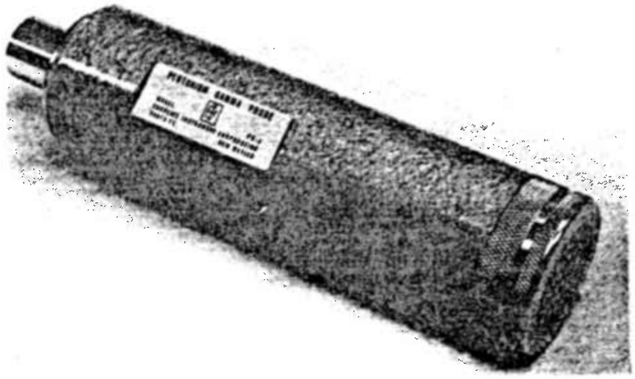


Figure 4-5. PG-1 Detector Assembly

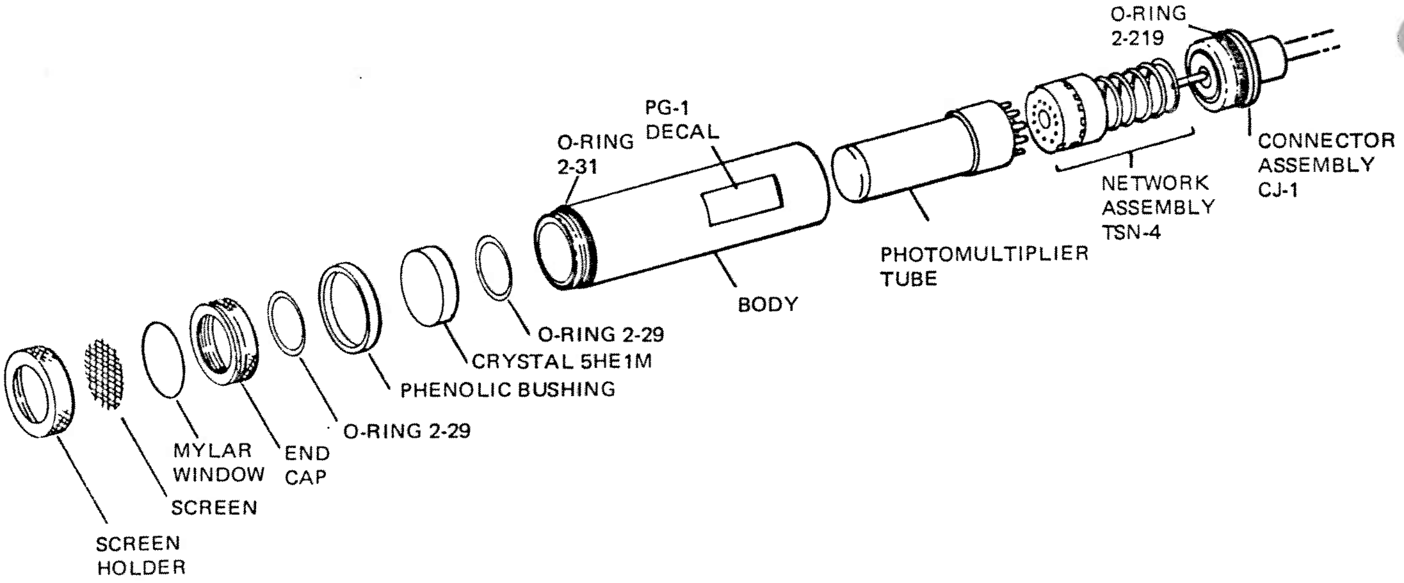


Figure 4-6. Composite View of PG-1 Parts Assembly

Should this fail to correct the fault, it is suggested that the following checks be made:

1. Check supply voltage from the battery pack (5.8 more volts). Also at contactor A of the P-8A assembly (4.7 ±0.2 V).

2. Check HV output to detector (1240 VDC ±30 V). Replace P-7 assembly if no voltage is present.

3. Replace P-8A Amplifier-Trigger Assembly.

4. Replace P-9A Meter Accessory Assembly.

5. Check continuity of subassembly wiring and components. See paragraph E-2.

G. REPLACING DETECTOR FACE

1.AC-3 (see Figure 4-3 and 4-4)

In the event a detector face is contaminated beyond use or holes and scratches make the detecor unusable, the face should be replaced.

To replace the detecor face, remove the six screws around the face, pull the face assembly from the housing, being careful not to allow the optical prism to fall from the housing. Remove the outer O-ring from the defective face. Take a new face and hook the O-ring seal around the plastic portion of the face assembly. Push the face into the housing, being careful that the prism is lined up with the mounting lugs in the head. Replace the six screws and tighten firmly.

Generally, it will be necessary to let the detector sit for approximately 1/2 hour or more to allow the new face to dark-adapt due to the afterglow of the ZnS when exposed to light. The meter may even peg on the X1 scale due to this afterglow.

When the instrument has dark-adapted and without an alpha source present, adjust the discriminator until a very small meter deflection of several cpm is noted on the X1 scale. This can best be done by adjusting to approximately 10 cpm as heard through the earphone. This is the photomultiplier noise level. Check the detector with a check source. If the reading is different from the calibrated value, further alpha measurements must be corrected by the same factor until the unit can be recalibrated.

2. PG-1 (see Figure 4-5 and 7-2)

If the aluminum window of the PG-1 should be damaged, a higher than normal background count will be indicated by the instrument. A higher than normal incident gamma background will cause a similar reaction. A recommended method used to determine if the window is damaged is to point the detector toward the sun or a strong artificial light. If the background count should increase appreciably the aluminum light tight window has been damaged. The aluminum window and crystal should be replaced. The mylar protective window in this case may also show evidence of damage and should be replaced.

Should there be no change in background cpm when the above check is done, then all subsequent readings should have a correction factor applied to them until the background cpm returns to normal.

SECTION V
SPECIAL INSTRUCTIONS

A. PREPARATION FOR USE

1. Initial Receipt

When the PAC-1SAGA is initially received it should be unpacked and the instrument and accessories checked for completeness and condition.

2. Shipping Damage Check

Remove the PAC-1SAGA from its case and inspect for any shipping damage, such as loose or broken wires, loose terminals, sockets and damaged meter.

3. Battery Installation (see paragraph D below for types of batteries)

Install batteries if they have been shipped separately. Be sure to align batteries according to polarity. When replacing the battery box cover, align the stationery key pin with hole in cover provided.

4. Reassemble

a. Replace instrument in its case and fasten spring latches. See Section IV, A.

b. Install detector cable.

c. Install AC-3 detector assembly.

5. Operational Check

a. Turn scale detector switch to X1K scale.

b. Press BATT CHECK switch and check battery condition.

c. Remove detector face protective cover.

d. Place check source on detector face.

e. Set detector selector switch to AC-3.

f. Set scale selector switch to scale that matches check source reading.

g. The meter should indicate this value within ±20%. If it does not, refer to Section IV, Calibration, and perform calibration adjustments.

h. Turn scale selector switch to OFF. Replace detector face protector.

i. The instrument is now ready for use.

B. SHIPPING THE INSTRUMENT

1. Thoroughly clean the instrument and accessories and if possible, check for any contamination.

2. Set scale selector switch to OFF.

3. Remove batteries.

4. Remove detector and cable.

5. Place the PAC-1SAGA main instrument in a plastic bag. In very humid areas, place a dessicant compound in the bag also. Evacuate as much air as possible and seal the bag.

6. Treat the accessories in the same manner as the instrument using one or more plastic bags.

7. Pack in a shipping carton large enough to accommodate the instrument and accessories with several layers of flex-hair or equivalent for shock and vibration protection. Separate the assorted plastic bag to prevent damage from rubbing together.

C. STORING THE INSTRUMENT

1. Short Term Storage

a. Clean the instrument and accessories thoroughly and if possible, check for any contamination.

b. Remove batteries if the instrument is to be inactive for 30 days or longer.

c. Store in a clean, dry place.

2. Long Term Storage

It is recommended that the instrument and accessories be treated in the same manner as is recommended for shipping in paragraph B above, omitting the packing and shipping container.

D. BATTERY SELECTION AND OPERATING CONDITIONS

The instrument upper operating temperature limit is governed by component limits. The lower temperature limit varies with the type of battery used. Any of the battery pack assemblies will give satisfactory results in extreme low temperatures (-40°F) for one to four hours of continuous operation. However, when operating for longer periods under adverse conditions the following criteria are suggested:

1. BP-1(-X) Battery Pack Assembly with D-cells.

   a. Carbon-Zinc (-1) or RM-42 Mercury (-2) +15°F (-9.5°C).

   b. Alkaline (-3) or Ni-Cad (-4) -20°F (-28.9°C).

2. BP-2(-X) Battery Pack Assembly with special batteries.

   a. Yardney LR-5 (-1) -40°F (-40°C).

   b. Mallory Mercury (-2) +15°F (-9.5°C).

SECTION VI
PARTS LIST

A. ASSEMBLIES

The following assemblies make up the standard PAC-1SAGA Portable Alpha Counter. These assemblies are available from Eberline Instrument Corporation. Complete customer service for the repair and/or reconditioning of these assemblies is available.

10294-00	PAC-1SAGA (Basic)
P-7	Power Supply Module Assembly
P-8A	Amplifier Trigger Module Assembly
P-9A	Meter Accessory Module Assembly
BP-1-1	Battery Pack Module Assembly (standard issue). 5 each size D standard dry cells in a modular container. See Section V, D.
CJ-2	Connector, can mounted
AC-3-7	Alpha Detector Assembly with AC-3FP Detector Face Protector
CA-5-36	Detector Cable Assembly

B. ACCESSORIES

The following accessories and/or assemblies may be used with the PAC-1SAGA to expand the versatility of the instrument. These items may be substituted in lieu of certain items in the standard "make up" of the instrument for special purpose application. Refer to Eberline Instrument catalog concerning the use of these items. Should further question arise, contact the sales department, Eberline Instrument Corporation, or a regional office of Eberline.

SK-1	Speaker Assembly
BP-2-1	Yardney Wet Cell Battery Pack Assembly
BP-2-2	Mallory Mercury Cell Battery Pack Assembly
CS-15	Thorium Alpha Check Source
S94-1	Four Standard Plutonium Calibration Sources
PG-1	Gamma Detector Assembly
AC-3M-2	Alpha Attenuator Mask
BA-201	Headset, single phone
10031-B99	Carrying Strap, 62 inches long

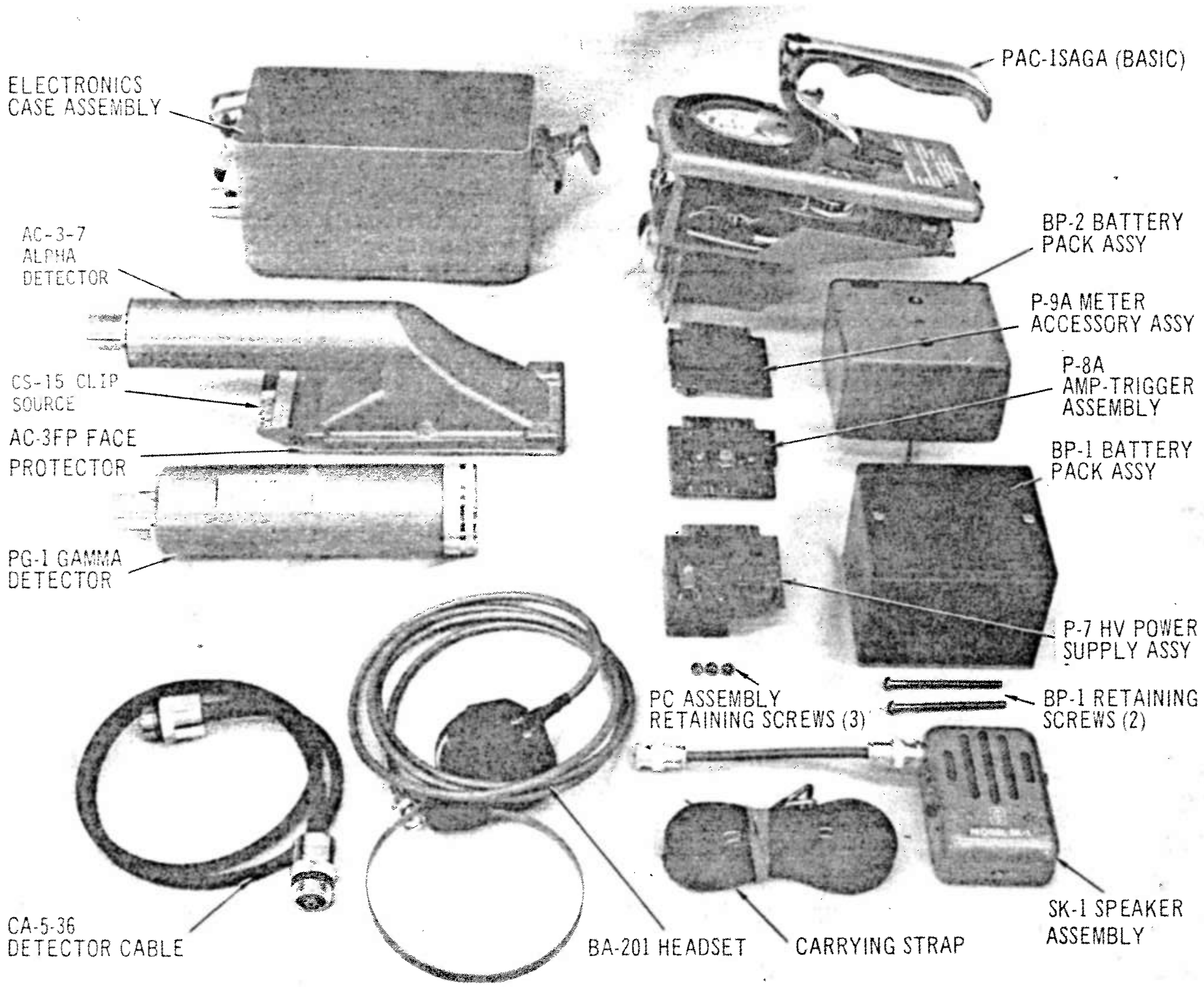
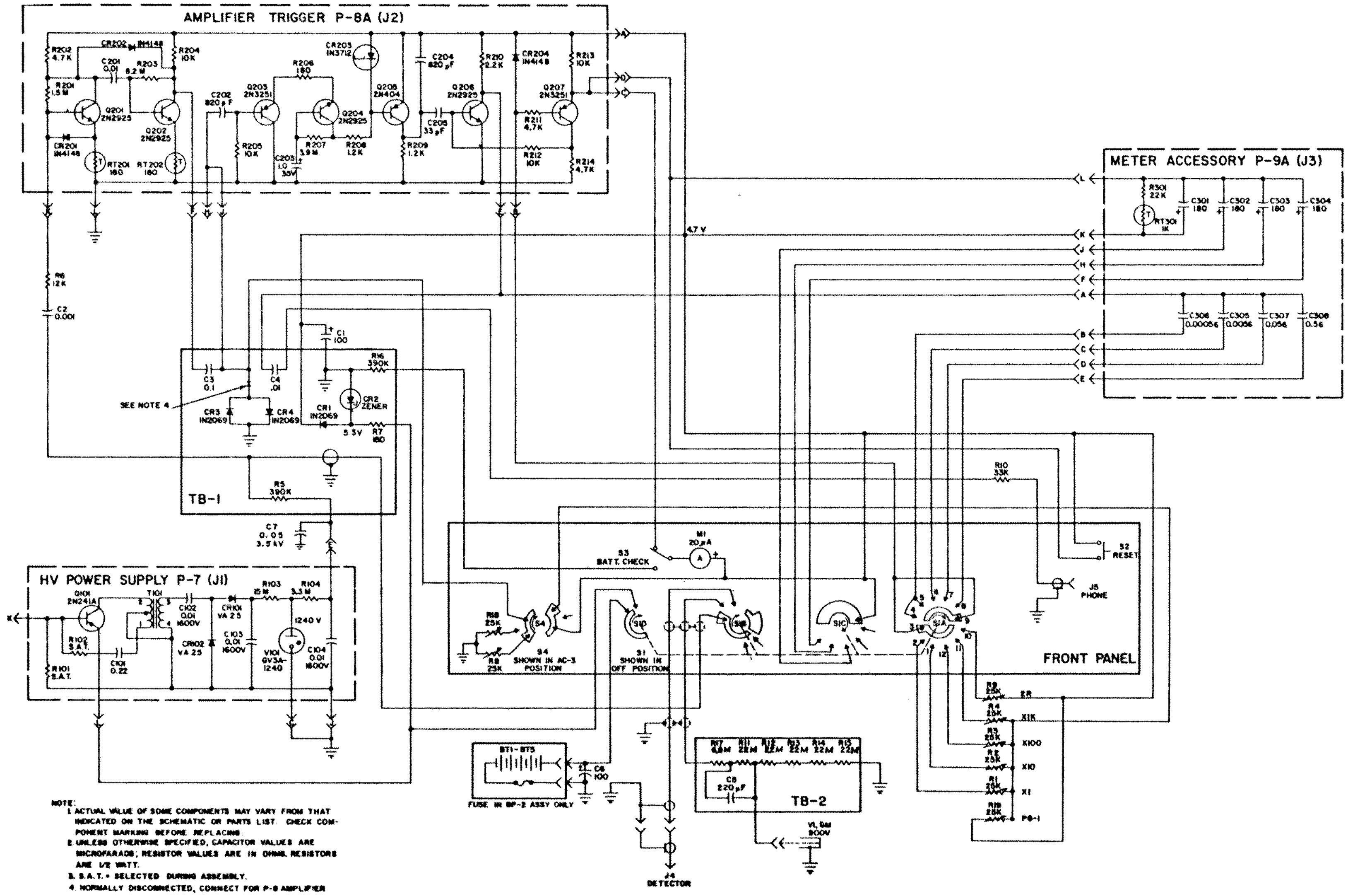


Figure 6-1. Composite Parts of the PAC-1SAGA and Accessories

REF DESIG	PART	DESCRIPTION	MFR AND PART NO
1. CHASSIS AND COVER ASSEMBLY, PAC-1SAGA			
C1, C6	Capacitor	100 μF, 10V, Tantalum	SCM107GP010A4 Texas Instruments
C2	Capacitor	0.001 μF, ±20%, 1600 VDC Ceramic	808-001Z5V0120M Erie
C3	Capacitor	0.1 μF, 200 V, Paper	P123ZG Aerovox
C4	Capacitor	0.01 μF, 200 V, Paper	P123ZG Aerovox
C5	Capacitor	200 pF, ±20%, 1 kV Disc Ceramic	HI Q Aerovox
CR1, CR3, CR4	Diode	1N2069	
CR2	Diode	Zener, 5.3 V, ±0.2 V at 1 mA	10416-A24 EIC
J1, J2, J3	Connector	Socket	K10S Winchester
J5	Connector	Phone UG657/U	
M1	Meter	20 μA, Meter Scale	10244-B07 EIC
R1, R2, R3, R4, R8, R9, R18, R19	Potentiometer	25k, Log Taper	GA2M028S253RC Allen Bradley
R5	Resistor	390k, 1/2W, ±10%, Carbon	
R6	Resistor	12k, 1/2W, ±10%, Carbon	
R7	Resistor	180 Ω, 1/2W, ±5%, Carbon	
R10	Resistor	33k, 1/2W, ±10%, Carbon	
R11, R12, R13, R14, R15	Resistor	22 M, 1/2W, ±5%, Carbon	
R16	Resistor	390k, 1/2W, ±5%, Carbon	
R17	Resistor	6.8 M, 1/2W, ±5%, Carbon	
S1	Wafer Switch		10125-67 EIC
S2	Switch	Reset	39-12 Grayhill
S3	Micro Switch	Push button	1PB5 Minn-Honeywell
S4	Switch		10294-B03 EIC
V1	Tube, Detector	900 V Geiger Tube	10450-B03 EIC
2. BATTERY PACK ASSEMBLY (BP-1) See Paragraph A and B above			
BT1, BT2, BT3, BT4, BT5	Batteries	D-cells	See Accessories
3. P-9A RATE METER ACCESSORY ASSEMBLY			
C301, C302, C303, C304	Capacitor	180 μF, 6 V, Tantalum	SCM187GP6A2 Texas Instrument
C305	Capacitor	0.0056 μF, 200 V	Sprague 192P
C306	Capacitor	0.00056 μF, 200 V	Sprague 192P
C307	Capacitor	0.056 μF, 200 V	Sprague 192P
C308	Capacitor	0.56 μF, 200 V	Kemet KR56J35KS
R301	Resistor	22k, 1/2W, 5%	
RT301	Thermistor	1k, Grade 1	Carboloy 1D203

REF DESIG	PART	DESCRIPTION	MFR AND PART NO
4. P-8A AMPLIFIER-TRIGGER ASSEMBLY			
C201	Capacitor	0.01 μF, 100W VDC, ±20%	MC80V103AM Aerovox
C202, C204	Capacitor	820 pF, 100W VDC, ±20%	MC80V821AM Aerovox
C203	Capacitor	1.0 μF, 35W VCD, Tantalum	K1J35 Kemet
C205	Capacitor	33 pF, 100W VDC, ±20%	MC80V330AM Aerovox
CR201, CR202, CR204	Diode	Silicon, 1N914 or 1N4148	
CR203	Diode	Tunnel, 1N3712	
Q201, Q202, Q204, Q206	Transistor	Silicon, NPN, 2N2925 or equal	
Q203, Q207	Transistor	Silicon, PNP, 2N3251 or 2N3640	
Q205	Transistor	Germanium, PNP, 2N404	
R204	Resistor	3.0k, ±5%, 1/4W, Selected	
R201	Resistor	1.5 M, ±10%, 1/4W, Carbon	
R202	Resistor	4.7k, ±10%, 1/4W, Selected	
R214	Resistor	4.7k, ±10%, 1/4W, Carbon	
R203	Resistor	8.2 M, ±10%, 1/4W, Carbon	
R205, R212, R213	Resistor	10k, ±10%, 1/4W, Carbon	
R206	Resistor	180 Ω, ±10%, 1/4W, Carbon	
R207	Resistor	3.9 M, ±10%, 1/4W, Carbon	
R208, R209	Resistor	1.2k, ±10%, 1/4W, Carbon	
R210	Resistor	2.2k, ±10%, 1/4W, Carbon	
R211	Resistor	8.2k, ±10%, 1/4W, Carbon	
RT201, RT202	Sensistor	180 Ω at 25°C	TM 1/8 Texas Instruments
5. POWER SUPPLY P-7			
C101	Capacitor	0.22 μF, 200 V, Paper	P123ZG Aerovox
C102, C103, C104	Capacitor	0.01 μF, 2 kV	BL-510 Sprague
CR101, CR102	Diode	2500 PIV	Varo VA-25
Q101	Transistor	2N652	Motorola
R101	Resistor, Selected	1/4W, 5%, Selected 180k Nominal Carbon	
R102	Resistor, Selected	1/4W, 5%, Selected 2.2k Nominal Carbon	
R103	Resistor	15 M, 1/4W, 10%, Carbon	
R104	Resistor	3.3 M, 1/4W, 10%, Carbon	
T101	Transformer	Special	10031-B75 EIC
V101	Tube	1240 V Corona Regulator	GV3A-1240 Victoreen

SECTION VII
DIAGRAMS



NOTE:
1. ACTUAL VALUE OF SOME COMPONENTS MAY VARY FROM THAT INDICATED ON THE SCHEMATIC OR PARTS LIST. CHECK COMPONENT MARKING BEFORE REPLACING.
2. UNLESS OTHERWISE SPECIFIED, CAPACITOR VALUES ARE MICROFARADS; RESISTOR VALUES ARE IN OHMS. RESISTORS ARE 1/2 WATT.
3. S.A.T. = SELECTED DURING ASSEMBLY.
4. NORMALLY DISCONNECTED, CONNECT FOR P-8 AMPLIFIER TRIGGER USE ONLY.

Figure 7-1. General Schematic PAC-1SAGA

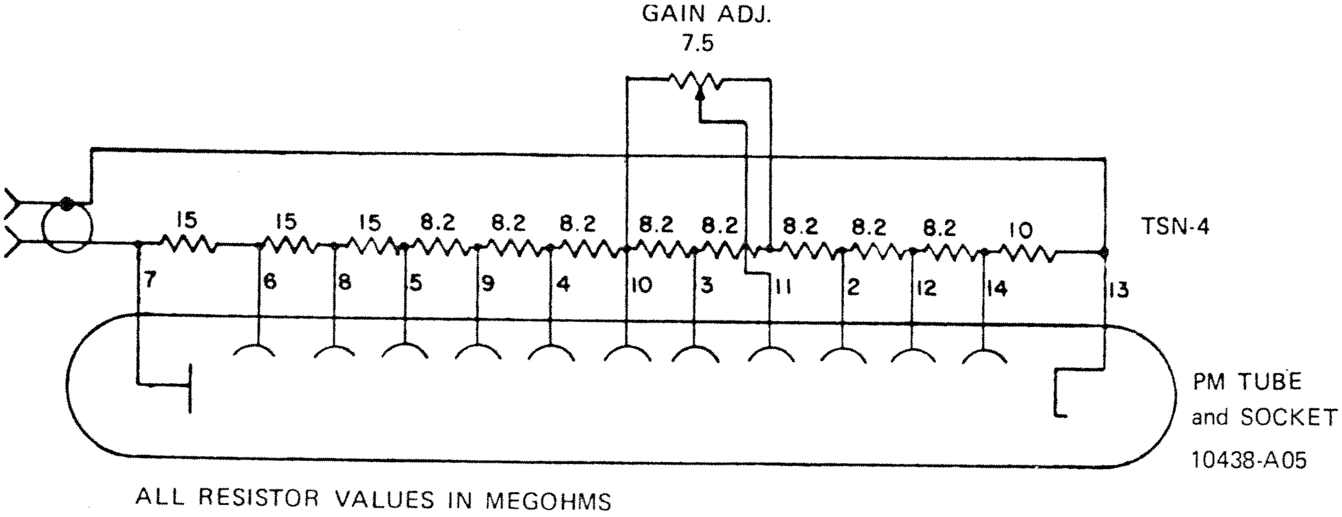


Figure 7-2. Schematic of PG-1 and AC-3 Detector Assembly

NO.	AN.	PER.	DESCRIPTION

This document is for Eberline in-house usage only and is subject to modification at any time. The process described herein is valid only if performed by Eberline personnel at Eberline facilities.

CHG.	APP.	DATE	DESCRIPTION	DATE	BY	CH'K
B		1/25/77	Retyped with revisions – Renumbered	1/22/77	BK	HART

QA APP. REV B 1-31-77

EBERLINE INSTRUMENT CORPORATION
SANTA FE, NEW MEXICO

DR.	BK	1/20/77
CH'K.	HART	1/25/77
PROJ. ENG.		
APP.		

(retyped version; for original, see Void File: 10294-A27)

PAC-1SAGA

CHECKOUT PROCEDURE

DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED

FRAC.	DEC.	ANG.
± 1/64	X.XX ± .015 X.XXX ± .005	± 1/2°

ALSO USED ON	EFF. WITH

SCALE

10429-A131 B Sheet 1 of 3

Test Equipment Required:

1. EIC Model MP-1 Mini-Pulser
2. High Impedance Voltmeter

Radioactive Calibration Standards Required:

1. Alpha Calibration Standards, Model S94-1 (Pu) (Certified)
2. Extra Alpha Calibration Standard, 10^6 CPM range (Certified)
3. Cesium-137 source of sufficient size to produce a 2 R/hr field (Certified)
4. Cesium-137 source of sufficient size to produce a 1000 R/hr field (Certified)
5. Distributed area Pu-239 Alpha Standard (X100 range) (Certified)

Initial Checkout and Alpha Calibration:

NOTE: (1) The Alpha ranges must be calibrated first before the PG-1 probe can be calibrated.
(2) The 2R gamma range should be calibrated after the Alpha ranges have been calibrated.

1. Turn all calibration pots 3/4 CW. Set the AC-3, PG-1 switch to the AC-3 position.
2. Turn instrument ON and measure instrument battery current with the clip-on milliammeter probe. The battery current should read less than 50 mA at 7.5V.
3. Check zener voltage measured across CR2 to be 5.3 ±.2V.
4. Check the battery test switch operation. The meter should read near the center of the green area.
5. Connect the AC-3 probe to the instrument.
6. Check the reset switch operation. Place probe on any calibration source for an upscale reading. Reset switch should return meter to zero when held depressed.
7. Adjust the input sensitivity with the DISCR. pot for 15 clicks per minute or less as indicated by counting the clicks with the earphone. This is the noise threshold of the photomultiplier tube.
8. Using the Eberline Model S94-1 Alpha Calibration Standards, calibrate each of the four ranges as follows:
   a. Set range switch to X1 position.
   b. Position the probe on the source holder plate for the X1 range.
   c. Adjust the X1 calibration pot to make the meter read the calibration source value. The meter fluctuation will be quite noticeable on this range.
   d. Adjust the X10, X100 and X1K calibration pots respectively using the correct standards.
   e. Rotate the probe 180 degrees on the source holder and check the reading on the X100 and X1K ranges only. The calibration pots are to be adjusted so the average reading of the meter with the probe in the two positions will equal the calibration source value within ±5%.
   f. All calibration pots should have ¼ turn CW rotation or more remaining after calibration.
   g. Instrument Linearity Test:
      1) Two alpha standard sources in the 10^6 CPM range are needed. (500,000 CPM to 1,500,000 CPM, sum of count rates less than 2,000,000 CPM)
      2) Take a reading using one of the 10^6 CPM source standards.

3) Cover up the 1st source to prevent any alpha reading and take a reading from the 2nd source at the opposite end of the probe holder.
4) Remove the cover from the 1st source and take a reading with both sources in place.
5) Add reading from Step 2) and 3).
6) The meter reading of both sources, step 4), must be equal to at least 80% of the two added source value.

h. The PAC-1SAGA instrument is now calibrated for measuring alpha radiation.

PG-1 Calibration:

NOTE: The PG-1 and PG-1 DISCR must be adjusted after the AC-3 alpha probe has been calibrated.

1. Connect the MP-1 to the PAC-1SAGA.
2. Set the AC-3, PG-1 switch to the PG-1 position.
3. Set the range switch to X100.
4. Set the pulser for 16,000 CPM, pulse height 10 mV negative.
5. Adjust the PG-1 calibration pot for a meter reading of 160,000 CPM (1600 x 100), ±5000 CPM.
6. Now connect the PG-1 probe to the instrument.
7. Adjust the PG-1 DISCR fully CW. If the PM tube is noisy the DISCR will need to be backed off CCW just enough to remove the tube noise. The background counts will remain approximately the same as long as the probe is on its plateau.
8. Using our alpha standard calibration source of the 10^6 CPM range, place the PG-1 over the source. The meter reading should be 7% or greater of the Alpha Standard counts.

Calibration of the 2R/hr Gamma Range:

The instrument is calibrated with a Cs-137 source.

1. The AC-3 probe does not need to be connected to the instrument during the gamma calibration. Normally the 2R/hr calibration pot should be initially set at ½ rotation for the first calibration point determination.
2. Place front of instrument toward the gamma source.
3. Place the instrument at the 1.5R/hr point on the calibration range. The distance is figured from the center of the detector tube to the source.
4. Adjust the 2R calibration pot for a meter reading of 1.5, ±0.05 R/hr.
5. Check the unit at the 2R/hr, 1.0R/hr and .5R/hr points. Readings must be within ±10% of full scale (±.2R).
6. Check the 2R/hr range for saturation in a 1000R/hr field. Instrument shall remain in this field for a minimum of 30 sec. and meter shall remain pegged.
7. Instrument is now calibrated for the 2R/hr gamma range.